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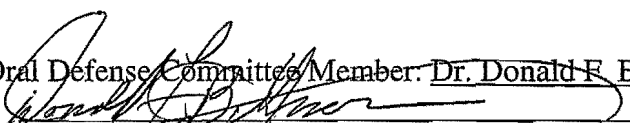
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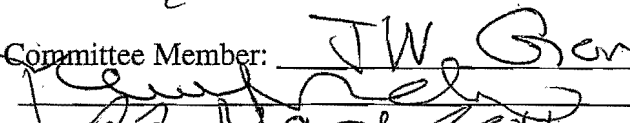
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Mentor and Oral Defense Committee Member: Dr. Donald F. Bittner, Professor of History

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## Executive Summary

**Title:** US Navy Littoral Combat Ship (LCS) Capabilities, Possible Missions, and Modules to Support Future USMC Operating Concepts

**Author:** LCDR Edmund J. Handley

**Thesis:** The LCS is the only U.S. Navy ship currently designed to operate in relatively shallow water with mission modules to support a variety of operations; to such it conforms to the Commandant of the Marine Corps (CMC) call for the USMC to “return to the littorals.”

**Discussion:** The USN, USMC, and USCG new document, *A Cooperative Strategy for 21st Century Seapower*, outlines the USMC returning to its maritime roots and recognizes that amphibious warfare is a necessity where the littorals will be future hotspots for global conflict. The U.S. Navy’s current 30-year shipbuilding plan does not build enough ships to meet the requirements for a two Marine Expeditionary Brigade (MEB) requirement. With future constraints on shipbuilding due to budget considerations, the LCS will need to play an integral part for the USMC and Navy in meeting their two core missions of assuring littoral access and conducting complex multifaceted crisis response operations. Admiral Vernon Clark’s *Seapower 21* (2002) strategy identified existing gaps in littoral capabilities as a lack of enhanced mine warfare capability, lack of shallow-water Anti-Submarine Warfare (ASW) capability, and lack of an effective counter to small craft threats.

The LCS will be able to carry different and interchangeable modules depending on a current mission. With the core-focused mission modules of Mine Warfare (MIW), ASW, and Surface Warfare (SUW), the LCS will fill these gaps while the inherent capabilities of the LCS seaframe of large flight deck, large internal mission bay, and speed can tender a host of other missions. Possible missions with envisioned modules include mobility, reconnaissance and CSAR, AFTP, Security Cooperation (SC), SOF, EMIO and NSFS. To meet these missions more effectively, the recommendation is to field a new module for NSFS and a personnel module for mobility to support SOF, EMIO, Security Cooperation and Humanitarian Assistance and Disaster Relief (HA/DR). The LCS with a significant force level in the fleet will provide outstanding force protection as a MAGTF ship in an ESG and permit longer uninterrupted power projection operations. The LCS class, while independently deployable, operates better in squadrons of two to three LCS vessels and the Joint High Speed Vessel (JSHV) where they have mutual support and sustainment. This ship with the appropriately designed modules has the potential to support a myriad of evolving USMC concepts of operations, e.g. Distributed Operations, Sea Basing, etc.

**Conclusion:** With modular multi-mission adaptability, high-speed, and shallow draft, the LCS gives the Joint Task Force commander (JTFC) a flexible platform that accommodates changing tactical requirements while opening up a much larger area of seaborne operations and meets USMC future operating concepts.

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## ***PREFACE***

I chose to study the LCS as it is the U.S. Navy's answer to future littoral warfare. Having served on the Navy's other Littoral Combat ship – the Patrol Coastal class, I was curious how the LCS was built and what it can bring to the fight. While assigned to Maritime Expeditionary Squadron Two (MSRON2), I was in charge of physical security for the USS *Independence* (LCS-2) ship commissioning in Mobile, Alabama and became intrigued in the design. Additionally, during the maiden deployment of USS *Freedom* (LCS-1), I deployed a MSRON2 Visit Board Search and Seizure (VBSS) team and became familiar with the operation of an LCS.

This MMS has application to several areas of study. These include future warfare, joint operations, and amphibious operations. The USN current shipbuilding plan does not project building enough ships to meet amphibious lift requirements for future MAGTF operations. How can we meet the need for amphibious lift using today's shipbuilding plans? *Marine Corps Operating Concepts (MOC)*, 3<sup>rd</sup> edition, June 2010 outlines future operations in the littorals. How can the MAGTF assure access in the littorals while maintaining force protection of the Expeditionary Strike Groups? This paper explores using the LCS as an option to fill these hull shortfalls in order to meet the USMC operating concepts of assuring littoral access and proven crisis response operations.

The LCS is the only U.S. Navy ship currently designed to operate in relatively shallow water with mission modules to support a variety of operations. As such, this vessel with the appropriately designed module(s) has the potential to support a myriad of evolving USMC concepts of operation, e.g. Distributed Operations and Sea Basing. It thus conforms to the Commandant of the Marine Corps (CMC) General James T. Conway's call for the USMC to "return to the littorals." This paper will explore the following questions:

- How can the LCS and currently planned LCS modules be used to support USMC warfighting functions and future operations?
- What new modules (such as a “manpower module” or “fire-support module”) should be developed to support specific missions?
- What is the best way to interface the LCS (and accompanying USMC modules) with other planned MAGTF support vessels of a Sea Base?

The paper is presented in two parts: the main paper discusses concepts while the appendices focus on system technical information, possible missions, and recommendations to improve the mission modules. There are two competing LCS hull designs: one a Lockheed Martin team and the other by a General Dynamics team. I believe the Navy has a good understanding of the strengths and weaknesses of each LCS ship design. The Lockheed version, for example, is the better design for supporting small boat operations, while the General Dynamics model is better at conducting helicopter and unmanned aerial vehicle flight operations. A recommendation would be to pair both versions in a squadron to maximize mission flexibility while taking advantage of each design during an operation. What this paper will not do is evaluate the two classes of LCS currently built and tested under a competitive bid contest. That would serve no valid purpose, for on December 29, 2010, the Department of Defense, with congressional approval, awarded a contract to build 10 ships each to Lockheed Martin and General Dynamics. I believe this decision was influenced by the successful deployment of USS *Freedom* LCS-1 completed on August 20, 2010. Whether the U.S. Navy intends to build both hull types or consolidate to one hull type to build the projected 21<sup>st</sup> through 55<sup>th</sup> hull has yet to be determined.

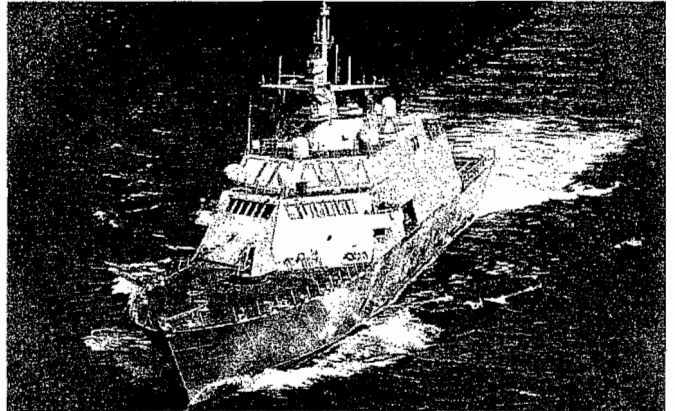
Research has been a challenge due to non-release of proprietary ownership information under a contract evaluation. Since the LCS is a contemporary subject, most of the research has been on the internet and military technical sites that focused on design information and evaluations. The Congressional Budget Office (CBO) and Congressional Research Service

(CRS) LCS papers, and articles by Undersecretary for the Navy Robert Work and Ronald O'Rourke have proven to be exceptional valuable research sources.

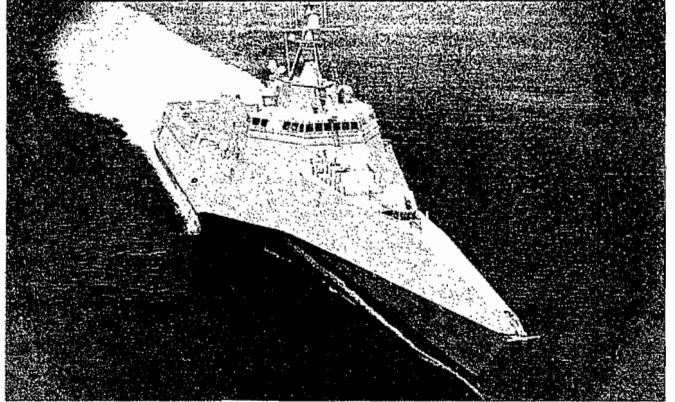
I wish to thank my wife, Kathleen, and daughters, Meghan and Rachel, for their support and encouragement in helping me complete this paper. I especially want to express my sincere gratitude to Dr. Donald F. Bittner whose guidance and friendship have made this paper possible.

**“The Navy’s Choice: Which One?”**

**USS *Freedom* LCS-1**



**USS *Independence* LCS-2**



**“THE NAVY DECIDES: BOTH!”**

## LCS DEVELOPMENT BACKGROUND

The USN, USMC, and USCG document, *A Cooperative Strategy for 21st Century Seapower* (2007)<sup>1</sup> outlines the USMC returning to its maritime roots and recognizes that amphibious warfare is a necessity where the littorals will be future hotspots for global conflict. With numerous countries building coastal navies and competing over resources, future disputes will center on island occupations to control exclusive economic zones of the continental shelf areas. This possible island and coastal warfare will require a ship to operate in the littorals and provide an operational platform for USMC expeditionary operations.

In August 2010, Undersecretary of the Navy Robert (Bob) Work spoke at a military strategy forum in which he outlined the Marine Corps Combat Development Command (MCCDC) agenda for the Force Structure Review Group (FSRG) to determine the post-Afghan Marine Corps. The agenda highlights the Marine Corps will “more reflect its naval character.” Marines will begin operating from a variety of new platforms such as the Littoral Combat Ship and Joint High Speed Vessel and should develop “with new and innovative ways to deploy Marines in smaller packages, with distributed operations<sup>2</sup> capabilities.” Mr. Work also noted the Corps and the Navy have settled on a fleet of 33 amphibious ships, having deemed the “high-end requirement” of 38 ships unaffordable.<sup>3</sup> The agenda emphasizes the major role the LCS is to play in the future USMC.

The concept of a Marine-carrying LCS is not new. The idea of using a small, high-speed ship to transport Marines first originated in the late 1930s when WWI destroyers were converted to high-speed transports (APD). Capable of 25 knots, these APDs carried four LCVP landing craft and could embark 145 Marines. In WWII, 36 destroyers (DD) and 96 destroyer escorts (DE) were converted to APDs. The DE version was limited to 23.5 knots and could embark 160

marines. Both types of APDs saw wide-ranging combat in WWII and the Korean War. Figure (9) on page 35 shows the *USS Stringham* (APD-6) after APD conversion. A LCS in this descendent role, with its high speed and helicopter capability, could provide a most versatile and useful capability for future naval operations in littoral areas.

In the *Marine Corps Operating Concepts (MOC)*, 3<sup>rd</sup> edition June 2010, the USMC has outlined two core missions: assuring littoral access and conducting complex multifaceted operations called crisis response. As the Marine Corps looks to the future and how it will be able to use emerging technology and available naval platforms to conduct expeditionary operations, the potential role the Navy's new Littoral Combat Ship (LCS) could play in future operations needs to be examined. The Navy is planning to build 55 of these ships. The LCS will be able to carry different and interchangeable modules depending on mission. Designed to operate in the littorals and built for the asymmetric age, the ship has the potential to support a wide variety of USMC related missions in support of Enhanced Marine Air Ground Task Force (MAGTF) operations (EMO) and Security Cooperation engagement missions.<sup>4</sup>

### LCS IN SHIPBUILDING PLANS

The Quadrennial Defense Review 2010 (QDR 2010) calls for a fleet of 313 ships to meet future maritime operational requirements.<sup>5</sup> Current shipbuilding forecasts do not support a fleet of 313 ships and do not meet the USMC's two Marine Expeditionary Brigade 33 amphibious lift-capacity requirement.<sup>6</sup> The MAGTF then needs a hull that can effectively meet all the challenges listed under the EMO development points and focused on what former CMC General James Conway calls the USMC "return to the littorals."

As shown in Table (2) on page 59, the USN 30-year shipbuilding plan (mandated by Congress) builds 276 ships but does not ensure enough ships to meet the requirements of a 313



ship Navy considering ship lifecycles and decommissioning schedules. Since the 2006 30-year Shipbuilding plan, there have been additional pressures on USN shipbuilding numbers that depart from the 313-ship goal. For instance, the Navy's new mission of ballistic missile defense (BMD) requires a force of 38 cruiser (CG) or destroyers (DDG).<sup>7</sup> The increased need for BMD assets will mean there are fewer DDGs to deploy in Expeditionary Strike Groups (ESG). With the reduced procurement of the *Zumwalt* destroyer class (DDG-1000) to three hulls and the cancellation of the CG-X program due to increasing costs, the Navy has decided to restart the *Arleigh Burke* (DDG-51) destroyer class.<sup>8</sup> Within the category of support ships, the USN has decided to build 23 Joint High Speed Vessels (JHSV)<sup>9</sup> vice the original shipbuilding plan for three JHSV ships. This will add strategic sealift after the cancellation of the Maritime Prepositioning Force (Future) MPF(F) ship squadron.<sup>10</sup> Without increasing the shipbuilding budget, all these additional ship requirements will mean fewer ships constructed under the original 2006 30-year plan. Compounding the problem, there is disagreement in the shipbuilding cost estimates between Congress and the Dept. of the Navy. The USN estimate for the five-year shipbuilding plan is \$15.9 billion per year (FY2010 dollars), but a May 2010 Congressional Budget Office (CBO) report estimates the plan would require a \$19 billion per year expenditure (an additional 19%). The report also cites the Navy's implied ship requirement for 2011 as 323 ships, not 313 as represented in table (6) on page 62.<sup>11</sup>

Indicated by tables (1) and (2) on page 59, the LCSs and JHSVs account for about 25% of the 313-ship requirement over the 30-year plan but they account for 50% of the ships in the current five-year plan. This makes the LCS and JHSV ships affordable in the near term to procure an average of 10 ships per year for five years within the existing budget.<sup>12</sup> The LCS with a significant force level in the fleet could provide force protection as a MAGTF ship in an

ESG. The LCS class could also be independently deployed in the Security Cooperation (SC)<sup>13</sup> MAGTF mission.<sup>14</sup> The amphibious dock and landing ships (LSD/LPD) – normally part of an ESG – with their crews of 400 are a large asset commitment to deploy frequently for a SC mission. The LCS crew of 45 plus the trainers would be a more economical choice and a better fit with partnership nations in the littorals.

## HISTORICAL - A SHIFT TO A LITTORAL MARITIME FOCUS

With the end of the Cold War in the early 1990's, a deep blue ocean threat from the Soviet Union fleet no longer existed. This signaled a change in priorities from employment of naval forces to project power at sea to a focus on littoral regions and joint expeditionary operations to project combat power from the sea.<sup>15</sup> With Department of the Navy's ...*From the Sea* whitepaper, the Naval Doctrine Command was created and began to develop a new maritime strategy required for the future littoral warfare. In 1994, the Navy subsequently released the whitepaper *Forward...From the Sea* that outlined littoral strategy.<sup>16</sup> This new strategy acknowledged the specific threats of mines, sea-skimming anti-ship cruise missiles (ASCM), and tactical ballistic missiles that could strain the capabilities of the current force structure. Former CNO, Admiral Vernon Clark's *Sea Power 21* October 2002 strategy identified existing gaps in littoral capabilities as lack of enhanced mine warfare capability, lack of shallow-water Anti-Submarine Warfare (ASW) capability, and lack of an effective counter to small craft.<sup>17</sup>

## THE LITTORAL ENVIRONMENT

Current joint doctrine defines the littoral mission as follows: the littoral area contains two parts. First is the seaward area from the open ocean to the shore, which must be controlled to support operations ashore. Second is the landward area inland from the shore that can be supported and defended directly from the sea. Control of the littoral area is often essential to

three-dimensional superiority. Naval operations can provide for the seizure of an adversary's port, naval base, or coastal air base to allow entry of other elements of the joint force.<sup>18</sup> Figure (10) on page 36 provides a view and definition of the littoral region. The character of the littoral operating environment is as follows:

- Complex – Shallow waters, archipelago, temperature, and salinity layers makes hiding easy and detection difficult
- Heavy sea traffic – ferries, merchant ships, fishing and pleasure boats
- A broad spectrum of threats – Anti-ship Missiles, Mines, Torpedoes,
- Artillery, Swimmers, Small units
- Short distances – Lack of space for defense in depth and for maneuvering
- Short reaction times<sup>19</sup>

In addition to the intricacies of navigating in shallow and confined water space, the littorals can harbor threats such as quiet diesel submarines and small fast attack crafts that can hide among commercial shipping and execute a coordinated multi-unit attack. Besides the conventional threats, other threats utilized by an asymmetric-minded enemy will continue to evolve using commercial-off-the-shelf (COTS) guidance technology. The October 2000 attack on the *USS Cole* (DDG-67)<sup>20</sup> in Yemen and the 2006 Hezbollah surface-to-surface C-802 missile attack on the *INS Hanit*, Israeli ship *Eliat* class, illustrate the dangers posed by these asymmetric threats.<sup>21</sup> The 17 May 1987 Exocet missile attack on the *USS Stark* (FFG-31)<sup>22</sup>, and the 18 February 1991 mine hits on the *USS Tripoli* (LPH-10) and *USS Princeton* (CG-59)<sup>23</sup> portray the conventional dangers that lurk in the littorals. Figure (11) page 36 shows these littoral threats.

### HISTORICAL – LCS DESIGN CONCEPTS

In order to assess how to fight in the above environment, in 1998, the Navy commissioned a study to determine what new naval concepts would be necessary to operate in the heavily defended littorals. The result: “*Streetfighter*.” Vice Admiral Arthur Cebrowski, head of the Naval War College and Navy Warfare Development Command and the father of the

“*Streetfighter Ship Concept*,” coined four topics regarding U.S. Navy future requirements to operate in the littorals against a networked or disassociated hybrid enemy:

- a) Networks should be the central organizing principle of the fleet, with sensing and fighting power distributed across multiple manned and unmanned platforms.
- b) The fleet sensor component should collect, collate and interpret data faster than any enemy who was not networked to the same degree, giving US forces a major competitive advantage through “speed of command.”
- c) The fleet should become the nation’s “assured access” force.
- d) Numbers of hulls count (“quantity is its own quality”) and consequently the fleet’s combat power should be distributed over as many interconnected platforms and systems as the budget allowed.<sup>24</sup>

To meet Vice Admiral Cebrowski’s future requirements, a hull needs to be a Network centric and fast a modular platform capable of adapting to the force, shaped to the mission, and cost effective.<sup>25</sup> The LCS was in concept designed to be the hulls. The LCS must also successfully integrate into current and future joint operations. The foundation for the LCS design comes from Vice Admiral Cebrowski’s definition in the “*Streetfighter concepts*” study: “Assured access” referred to the ability of the fleet to overcome coastal defenses to enable air and ground forces to conduct operations on or over enemy territory. The enemy could be expected to oppose U.S. operations with anti-access and area-denial strategies (A2/AD). Therefore, by definition, access to an area can only be achieved by engaging the enemy in its own littoral regions.<sup>26</sup> The LCS with its unmanned systems is a set of connectors in *Sea Power 21* FORCEnet<sup>27</sup> that provides intelligence, surveillance, reconnaissance, data relay, and a strike component for the MAGTF and ESG while keeping personnel out of the dangerous littoral areas.<sup>28</sup> See figure (11) on page 36 for littoral dangers.

When it came to littoral combat, the Navy’s main battle fleet – ESG, CSG, would destroy the land-based elements of the enemy’s A2/AD capability and conduct support for subsequent exploitation for Sea Basing and Sea Control operations.<sup>29</sup> Small-networked combatants would

undertake engagement on the seaward side of the littoral, including the protection of the ESG, CSG and the destruction of enemy coastal naval assets such as mines, submarines, Fast Attack Craft (FACs), and Fast Inshore Attack Craft (FIACs). This is the basis for assuring littoral access for all MAGTF missions: forward presence, maritime security, humanitarian Assistance/disaster relief (HA/DR), sea control, power projection, and deterrence outlined in *Naval Operation Concept 2010* (NOC 10).<sup>30</sup> Hence, the LCS class, designed and built for this role, would fit well in the ESG as that small-networked combatant and replace the FFG-7 frigates and MCM mine countermeasures vessels.<sup>31</sup>

While U.S. Navy officials have stressed that the LCS is not “*Streetfighter*,” the LCS has similar operational concepts of littoral-based, high-speed, reliance on automatic sensors, and smaller dimension that seem to fit in the “*Streetfighter*” design philosophy.<sup>32</sup> In 2009, from the Navy’s planning guidance in *LCS Wholeness Concept of Operations*, the Navy’s response to countering the littoral threats would be the LCS. The LCS force will be:

- a distributed force deployed in groups, as compared to single, multi-mission ships
- modular in design, mission flexibility, innovative crew manning
- interwoven, both tactically and operationally, with traditional power projection forces
- open architecture, able to integrate with and to leverage all-service information gathering and targeting capabilities.<sup>33</sup>

### LCS CONCEPT OF OPERATIONS

The conceptual design of the LCS was to be a small, maneuverable, cheap, and shallow-draft vessel capable of both high-sprint and low-cruising speeds to fill the existing capability gaps in the littoral first identified by Admiral Clark in his *Sea Power 21* strategy. These gaps were mine, shallow anti-submarine, and FAC/FIAC surface warfare areas. To mitigate the gap challenges, critical design features had to be reached by the marine engineers and architects for LCS to meet these mission capabilities.<sup>34</sup> Figure (12) on page 37 highlights the LCS Concept of

Operations in the littorals while table (4) on page 60 gives examples of mission warfare tasks and related capability gaps in the littorals. Per the *LCS Wholeness Concept of Operations*, the LCS is a reconfigurable single-mission ship. The seaframe contains the inherent ship self-defense capability with the ability to tailor to any littoral mission by inserting mission-specific Lego-like modules. The modules supporting the mission packages conform to a twenty-foot International Standards Organization (ISO) container and are assembled and plugged into the seaframe. The mission systems and associated unmanned vehicles interface with the seaframe C4ISR network and communicate with the other ships and aircraft. The mission modules are interchangeable, and they can be exchanged with another mission module from forward bases, maritime preposition ships, or via airlift.<sup>35</sup>

This gives the task force commander a platform that can adapt to any contingency. Table (3) on page 60 lists examples of LCS missions. The focused mission packages include the Mine Warfare (MIW), Surface Warfare (SUW) and Anti-Submarine Warfare (ASW) modules. Permanent blue and gold crews of 45-personnel each now rotate and operate the LCS seaframe every four months. The crew rotation maximizes the mission on-station time. The ships carry 21 days of provisions and are capable of underway replenishment for cargo and fuel. Operational availability is very high at approximately 90%. Mission specialists, who accompany the module, provide the separate logistics and support for operating the mission modules. The number of mission specialists is dependent on the focused mission package but do not exceed 30 personnel. The modular mission package design and small crew lowers the overall lifecycle cost of the LCS.<sup>36</sup>

#### LCS DESIGN - CORE CAPABILITIES

On 27 May 2004, the Department of Defense announced that team Lockheed Martin

(LM) Corporation - Maritime Systems & Sensors, Moorestown, NJ / Marinette Marine of Marinette, WI, and team General Dynamics (GD) - Bath Iron Works, Bath, MN / Austal of Mobile, AL were each awarded contract options for final system designs and construction of up to two Flight-0 Littoral Combat Ships (LCS). The Lockheed design is a high-speed semi-planing monohull: USS *Freedom* LCS-1. The General Dynamics design is a slender, stabilized, monohull, more commonly known as a trimaran: USS *Independence* LCS-2.

Each of these designs meets the performance requirements of the top-level requirements documents and achieves objective levels in several key performance parameters. Both designs achieve sprint speeds of over 40 knots as well as long-range transit distances of over 3,500 miles. The seaframes of each design can accommodate the equipment and crews of the focus mission packages and effectively launch, recover, and control the mission vehicles for extended periods in required sea states. However, there are different methods by which they launch and recover both aircraft and waterborne craft. In addition, the treatment of reconfigurable internal volume (available mission module space) in the two ships is quite different. The GD *Independence* design offers an especially large flight deck (7,300 ft<sup>2</sup>) and large mission bay (15,200 ft<sup>2</sup>) for its size, with a 3,500-ft<sup>2</sup> hangar. The LM *Freedom* Class ship has a smaller flight deck than the GD *Independence* Class at 5,200 ft<sup>2</sup>, but a larger 4,680-ft<sup>2</sup> hangar. The LM *Freedom* Class' LCS mission bay is under half the size, at 6,500 ft<sup>2</sup>. See appendix C page 28 for LCS design specifications and appendices D and E on pages 31 and 33 for ship illustrations.

The *Independence* flight deck can operate two Seahawk SH-60S/R<sup>37</sup> (or two Huey UH-1 / Cobra AH-1) helicopters simultaneously or one Super Stallion CH-53E<sup>38</sup> / Sea Knight CH-46<sup>39</sup> helicopter. The smaller *Freedom* flight deck can operate only one of the above helicopters at a time. The hanger bay of both designs can stow two SH-60s, but cannot support the large

helicopters. Three RQ-8B Fire Scout helicopter VTUAVs<sup>40</sup> may be substituted for one SH-60.<sup>41</sup> While the dimensions are similar for the CH-53E and the V-22 Osprey<sup>42</sup>, exhaust downward thrust of the V-22 is so hot that it exceeds the LCS flight deck thermal design limitations. In order to operate the V-22 the LCS flight deck would require structural modification.

Both ships' navigation, C4ISR, and other electronic systems incorporate Commercial Off-The-Shelf (COTS) technology. Data links will enable the ship to plug into the Navy's overall battle network. The LM and GD ships both have a BAE Systems Mk110 57mm naval gun<sup>43</sup> firing at a rate of 220 rounds per minute with a range of nine miles and .50 cal gun mounts. For anti-missile defense, the GD ship *Freedom* incorporates a RIM-116 SeaRAM<sup>44</sup> short-range anti-missile defensive system cued by integral radar with a Rolling Airframe Missile (RAM) launcher assembly containing eleven projectiles. The LM ship *Independence* has a Rolling Airframe Missile<sup>45</sup> (RAM) launcher assembly containing twenty-one projectiles cued by the sea frame radar. The *Freedom* uses the integrated combat management system (ICMS)<sup>46</sup> and the main mast carries the Tactical Data Link (TADIL) Link 16<sup>47</sup>, Link 11<sup>48</sup>, Cooperative Engagement Capability<sup>49</sup> (CEC), and the Sea Giraffe<sup>50</sup> radar. The decoy systems includes three Super Rapid Bloom Off-board Chaff<sup>51</sup> (SRBOC) and two Mk-53 NULKA<sup>52</sup> decoy launchers. The countermeasures suite will include ES 3601 tactical radar electronic support measures<sup>53</sup> (ESM). The combat management system for the *Independence* is the COMBATSS-21<sup>54</sup> and equipped with EADS TRS-3D C-band radar<sup>55</sup> for air and surface surveillance and weapon assignment and the Soft-Kill Weapon System<sup>56</sup> (SKWS) decoy launcher.<sup>57</sup>

Primary missions of both are the same: to ensure and enhance friendly force access to littoral areas. Access-focused missions include the following primary missions:

- a) Anti-surface warfare (ASuW) against hostile small boats
- b) Mine Counter Measures (MCM)



- c) Littoral Anti-Submarine Warfare (ASW)

The following secondary missions may include:

- d) Intelligence, Surveillance and Reconnaissance (ISR)
- e) Homeland Defense / Maritime Intercept Operations
- f) Special Operation Forces support
- g) Logistic support for movement of personnel and supplies

Current LCS mission modules to support above missions include the Mine, Surface, and Anti-Submarine Warfare Modules. Possible additional missions are detailed in appendix (K) page 51.

### MINE WARFARE – FOCUSED MISSION

Mine Warfare – Capability. The LCS's prime purpose in the MCM role is to support power projection operations at the tactical and theater levels. At the tactical level, the LCS will support the Joint Force Commander by undertaking Intelligence Preparation of the Operational Environment (IPOE) and first response MCM operations ahead of power projection forces.<sup>58</sup> The Mine Warfare mission package gives the U.S. Navy a major advantage over the Avenger (MCM)<sup>59</sup> Mine Counter-measures Class vessels. Off- board options for mine detection and neutralization include two helicopters or one helo and three VTUAVs for mine detection and neutralization, one Rigid Hull Inflatable Boat (RHIB)<sup>60</sup> or Spartan Unmanned Surface Vehicle (USV)<sup>61</sup> for mine detection, two AN/WLD-1 Remote Minehunting (UUV) System<sup>62</sup>, and one Explosive Ordnance Disposal (EOD) detachment. That is potentially three to four times the number of mine sweeping systems on board the *Avenger* Class minesweeper ships. The LCS with MIW module will be the first dedicated minesweeper the US Navy has deployed that can go faster than 14 knots. For MIW module details see appendix (H) on page 38.

The LCS and MIW package provides the Joint Task Force (JTF) commander a quick first-response to mine-laying activity with mine detection and avoidance capability that will enable MIW operations to be complete prior to the movement of CSG and ESG forces to the area

of operation. The LCS, equipped with seaframe combat suites, weapons and electronic counter measures can also conduct the mission without the need of escorts to provide FAC, FIAC, anti-ship cruise missile or air defense giving the task force “opposed MIW” capacity. With unmanned vehicles, the MIW package can clandestinely search for mines with reduced need for local air and sea superiority to protect the MIW forces.<sup>63</sup>

The LCS-MIW package is more responsive to afloat commanders with detection and identification of mines in the shallows and at all depths. With the enhanced “detect and avoid” and “detect to breach” capabilities of the LCS-MIW package, the commander has better undersea situational awareness for more precise navigation that reduces the demand on breaching assets. By reducing the time required to clear mines for contested littoral access, the LCS and the MIW package offers the JTF commander flexibility for course of action development in Operational Maneuver from the Sea (OMFTS)<sup>64</sup> and Ship to Objective Maneuver (STOM)<sup>65</sup> tactics.

Additionally, the MIW unmanned vehicles keeps human and mammals out of the minefield. The LCS and MIW package can clear eight breach lanes (figure (16) page 41) quickly per USMC MEB in accordance with NTTP 3-15.3 (MCM in Support of Amphibious Operations).<sup>66</sup>

Mine Warfare – Concept of Employment. As part of an ESG, the LCS working in groups of two to three hulls can provide a quick first response for the mine-counter mission (MCM) for the commander. The LCS squadron’s rapid sensor searches can locate and neutralize mines, or detect and avoid mines to establish Q-routes. Once the routes are clear of mines, the LCS would then conduct regular surveys by laying tripwire sensors to monitor enemy mine-laying activity to ensure clear port or beach access for the ESG. The LCS-MIW package allows for covert bottom mapping and survey to identify suitable Littoral Penetration Points (LPP) for MAGTF amphibious operations. In the opposed MCM mission, LCS and the MIW off-board systems will

monitor enemy mine-laying events and can attack enemy mine-laying vessels while maintaining DMER5 (Deployment, Management, Exploitation, Refueling, Repositioning, Recovering, Replacement, Redeployment) of MCM vehicles. The LCS can also provide the stealthy insertion of Very Shallow Water (VSW) EOD and dolphins from Navy Marine Mammal Program (NMMP). The LCS can rapidly and accurately lay mines for force protection or the ESG and MAGTF or deny access to the enemy. The LCS and MIW mission package offers flexibility to match OMFTS/STOM tactics by clandestine detection and identification of mines at all depths and with precision navigation capabilities that enhance the ability to avoid mines and reduce the demand on breaching assets while keeping personnel out of the mine danger area.

#### **SURFACE WARFARE – FOCUSED MISSION**

Surface Warfare – Capability. During the SUW mission, the LCS will provide commanders the capability to defeat the FAC/FIAC threat in the ESG operating area. The high-speed of the LCS allows for interception, screening, and self-defense with electronic deception to jam radar-equipped small boats. The SUW package with inherent UAV can search, track, and shadow small craft, and its helicopter can attack with high-rate-of-fire guns and hellfire missiles. The USV can deploy tripwire acoustic sensors and conduct ISR missions to provide early warning detection of small boat activity. The LCS-SUW mission package provides the task force commander with the ability to move naval forces through restricted waters while protecting the amphibious ships against swarm attacks by small fast craft. The SUW mission package with the speed of the LCS can sprint ahead as a scout and deploy the helicopter or UAV to extend the sensor range of the ESG. The LCS is also an ideal platform for the USMC to conduct Expanded Maritime Interdiction Operation (EMIO) and Security Cooperation operations.

Surface Warfare – Employment. The LCS with the SUW mission package will work in groups

of two to three to protect the ESG and MAGTF from the small boat attacks during transit of chokepoints and amphibious operations. The LCS networked with other ESG assets will build and manage the Common Operational Picture (COP) in the littorals by deploying acoustic-RF sensors along an ESG threat axis and harbors to provide early warning of a small boat activity. Once the sensors detect a FAC/FIAC threat, the LCS will launch manned and unmanned aircraft to identify and target small boat formations. Single larger crafts are engaged as point targets using targeting data from the helicopter or UAV with LCS large-caliber 30mm and 57mm guns, helicopter guns, or ESG assets. Swarm attacks are engaged as area targets using LCS large and small caliber guns set at high-rate-of-fire with wide dispersal patterns. See appendix (I) page 42 for details, and recommendations or modifications to improve the SUW module.

#### ANTI-SUBMARINE WARFARE – FOCUSED MISSION

Anti-Submarine Warfare – Capability. The ASW package gives a task force commander the capabilities to employ remote-controlled unmanned surface and semi-submersible vehicles with towed arrays to detect and attack enemy submarines in both deep water and littoral regions while reducing the risk to the major combatant (DDG and CG) ships. With the large number of dedicated ASW sensors, mobility and flexibility of vehicle employment, the LCS configured with the ASW module can provide three times the search capacity covering ten times the area of Arleigh Burke Class Destroyers (DDG). The ASW module, with the unmanned ASW sensor vehicles and helicopters, all networked with other units in the ESG, will greatly increase the situational awareness of the undersea battlespace.

The littoral region where the ESG conducts amphibious operations presents the greatest challenge to ASW due to the high ambient noise from high-density shipping and sound problems from coastal background acoustics. Existing AN/SQS-53 series low-frequency sonar suites on

DDGs and CGs suffer greatly in the littorals from reverberation that makes enemy submarine detection difficult.<sup>67</sup> In the littorals, the LCS-ASW package can conduct integrated undersea surveillance to detect and attack the difficult-to-track Air-Independent-Propulsion (AIP) submarines and diesel submarines on-battery in shallow water or resting on the sea floor.

Because of her fast speed and shallow draft, and the ability to conduct stealthy over-the-horizon ASW operations with remote vehicles, the LCS-ASW mission package reduces the time and the number of combatants needed to achieve and maintain access in the focused littoral region so critical to power projection from the sea.

Anti-Submarine Warfare – Employment. While capable of providing deep-water ASW, the main advantage of the LCS, is in providing the JTFC a first-response and shallow-water ASW capability. The LCS with ASW mission package will enter the littoral region ahead of the ESG and deploy unmanned vehicles to clear and defend the amphibious operation area or harbor. The LCS, operating at long distances along the anticipated threat axis from the ESG, can deploy tripwire sensors to warn of an approaching enemy submarine. Using remote-operated vehicles and sensors, the LCS can establish an ASW barrier to protect an amphibious operation area or littoral sea base. Networked with other surface and aerial platforms, after enemy submarine detection the LCS can conduct an urgent attack using the MH-60S/R Mk 54 torpedo system or guide other assets to engage the target. With long-endurance USV, UAVs, the LCS-ASW provides persistent coverage of a sea area and can sit at chokepoints or along Strategic Lines of Communications (SLOCs) to monitor submarine transits. Appendix (J) on page 47 lists ASW module details with improvement recommendations.

#### LCS CLASS ASSESSMENT

Is the Navy accepting too much risk procuring 55 LCS vessels without prototype testing

and concept of operations development prior to contract approval? Other critics contend the LCS design with reduced manning has a high risk for ship survivability, sustainability, and mission accomplishment. The same argument in 1999 doomed Admiral Cebrowski's "Streetfighter" concept due to tactical concerns regarding small ship overseas sustainability, payload limitations, and littoral threat assessments to single-mission vessels.<sup>68</sup>

Acquisition, Operations, and Development Concerns. LCS is the first U.S. Navy ship class procured prior to developing the ships Required Operational Capability (ROC) and Projected Operational Environment (POE) documents. The ROC and POE are guidelines that detail everything from a ship's mission statement, plan of operational employment, Naval Mission Essential Task List (NMEL) to ships manning document (SMD) for staffing requirements. Without those specific guidelines, the Navy has to rely on the Navy Warfare Development Command's *Littoral Combat Ship Concept of Operations* document to describe generically the LCS's mission, projected operating environment, and manning document. In a 2005 report to congress, the GAO was apprehensive about using unproven technologies in the LCS design and modules that could increase the acquisition costs and timeline. Additionally, there was no scheduled prototype testing in the LCS program. The rapid acquisition schedule for the LCS did not allow enough time for modifications and improvements to be incorporated into the flight 1 designs after discovering problems during flight 0 operations.<sup>69</sup>

Using technologies not thoroughly tested and developed to keep a rapid acquisition timeline incurs a high risk: when the technologies are delivered, the systems do not function as planned and subsequently require refit with more research and development.<sup>70</sup> The failures of the Non Line-of-Sight – Launch System (NLOS-LS) NETFIRES, WLD-1 remote multi-mission vehicle (RMMV semi-submersible) in the Anti-Submarine mission package and Advanced

Deployable System (ADS) in the Mine Warfare mission package validated those concerns of using undeveloped technology in the LCS. The NETFIRES, RMMV (ASW) and ADS thus have been cancelled from the LCS program.<sup>71</sup> The Navy's answer to the report was it was willing to accept this acquisition and development risk if the littoral gaps identified in Admiral Clark's *Sea Power 21* strategy were filled sooner rather than later. In the Navy's words, "The Navy intends for LCS Flight 0 to deliver an immediate capability to the fleet to address critical littoral anti-access capability gaps and to provide risk reduction for follow-on flights."<sup>72</sup> USS *Freedom*'s 2010 maiden deployment provided the opportunity to test the LCS Flight 0 design concepts in actual fleet operations, and certify the seaframe.

The USS *Freedom* LCS-1 completed a six-month deployment to the Pacific two years earlier than originally scheduled. The early deployment of *Freedom* with a SUW mission package gave the Navy a chance to validate several key factors: ship materiel condition, test plan acceleration, ship sustainment, integrated support plan, and crew training and certification. The *Freedom* proved its worth in fleet operations, conducting anti-drug, and security cooperation missions while integrated with a carrier strike group. The data collected by the Navy from the real-world deployment will prove invaluable in helping with future LCS integration in the fleet.<sup>73</sup>

LCS Sustainability. The Navy has also assumed a high risk for LCS sustainability in terms of logistics, endurance, and a small crew size. While the LCS carries 21 days of stores for 75 personnel, there is not enough storage to carry repair parts. The crew is also only trained and outfitted to conduct routine preventive maintenance on equipment and will have to rely on flyaway private contractor teams with voyage repair kits to make corrective repairs to machinery and systems.<sup>74</sup> With a minimum crew size, the LCS sailors perform numerous tasks outside their normal rating (designated area of expertise).

This “hybrid sailor”<sup>75</sup> is cross-trained in the unique LCS systems in a long training pipeline with an average duration of 484 days – a training period much greater than other ships. Typical en-route training for a sailor to a LSD is 126 days and 103 days to a DDG. The length of training for mission module sailors is similar to the LCS crewmember. Sailors on non-LCS ships can rely on similar ship and system designs and only require training in their specific rate prior to reporting for duty on any other platform. While this LCS cross- training enables savings from the economy of crew-size, the Navy assumes risk in its ability to identify and assign personnel to achieve the extensive training prior to reporting for duty on an LCS.<sup>76</sup> To harness this extensive training investment, the Navy needs to develop a LCS special designator to close loop sailors in the LCS community for more than just a two to five year tour.

The Navy assumes logistic risk with LCS as the ship does not meet the threshold endurance parameters identified in the Littoral Combat Ship Flight 0 Preliminary Design Interim Requirements Document (PD-IRD, February 10, 2003) shown in appendix (C) on pages 28-29. The fuel prediction model outlined by Lieutenant John P. Baggett in his thesis on *Logistical Analysis of the Littoral Combat Ship (LCS) Operating Independently in the Pacific* indicates that the both LCS designs do not meet all the endurance objective levels at various speeds.<sup>77</sup> These parameters are significant to insure the logisticians can properly plan refueling schedules to maximize the LCS greatest operational advantage, its speed. This reduced operating range requires the LCS to deviate from the required reserve fuel levels delineated in NWP 4-01.2, *Sustainment At Sea*, or deploy with a support ship or near a shore base while operating independently of an ESG. To meet the Navy’s requirement of mission package change-out in four days, mission modules will have to be stored at a forward support base, have dedicated airlift, or stored on a forward deployed Maritime Preposition Ship.<sup>78</sup> To alleviate this high-speed



constraint over an extended range, and meet the four-day timeline for swapping mission packages, a recommendation would be to deploy the LCS with a JHSV support ship (see figure (19) page 63 and design specifications on page 30).

LCS Survivability. The Navy acknowledges the high risk associated with LCS survivability. Due to the small size of both the LCS and its crew, the ability to survive a major weapons hit is questionable.<sup>79</sup> In March 2005, a U.S. Government Accountability Office (GAO) report voiced concerns the U.S. Navy did not fully assess the threat posed by a larger combatant armed with medium caliber guns, torpedoes, and anti-ship cruise missiles to LCS.<sup>80</sup> Both LCS designs are based on primarily the American Bureau of Shipping Naval Vessel Rules and High Speed Naval Craft Code commercial standards using aluminum and non-traditional hull forms. As such, there is no Military Standard modeling tool for determining the LCS seaworthiness after sustaining damage for the LCS Live, Fire, Test, and Evaluation program. Normally, without this data, there is more proxy testing during shock tests to determine hull vulnerabilities. The LCS is classified as a Level I survivability combatant ship but will not go through a traditional full shock hardening test required under the Capabilities Development Document due to possible damage on the non-shock hardened LCS systems. The only LCS shock test that will be conducted will be the mobility portion to retreat from an area after the ship sustains a hit. Based on these test deviations, it seems the ship will not be survivable after suffering a hit in a combat.<sup>81</sup>

The LCS small crew size is also a liability to survival. As evident by the hits suffered by the *Stark*<sup>82</sup> and *Cole*<sup>83</sup>, automatic damage control systems often do not operate after sustaining a major hit. Only the damage control efforts by the crew using portable DC equipment<sup>84</sup> saved those ships. This type of catastrophic casualty, called a major conflagration, places great demands on the crew. To save the *Stark*, its crewmembers had assistance from two other ship

crews that were operating in the same area. After the LCS suffers a first major hit, it is doubtful that the surviving crewmembers from the small crew would be able to conduct the necessary damage control to save the ship. At the very least, one hit on a LCS would be lethal.

## CONCLUSION

With the future constraints of the shipbuilding budgets, the LCS will need to play an integral part for the USMC and Navy meeting their two core missions of assuring littoral access and conducting complex multifaceted crisis response operations. Possible missions with envisioned modules include mobility, reconnaissance and CSAR, ATFP, Security Cooperation, SOF, EMIO, and NSFS. The strength of the LCS concept of operation is the variable modularity of the seaframe, high-speed maneuverability, shallow draft, and large flight deck.

Along with three-fixed SUW, MIW, and ASW core mission packages, the LCS has a range of innate capabilities that can support a large assortment of air and surface craft employing their sensors and weapons. What does this mean? As Under Secretary of the Navy Robert Work commented, “The LCS is less like a traditional ship and more like a highly flexible naval Swiss knife.”<sup>85</sup> The design attribute of high-speed allows the LCS to act as a first responder to meet many situations that can arise during an operation. The LCS with 45+ knots speed is exceptional well-suited to specific tasks that require an interception of a target vessel, tactical reconnaissance, or acting as a protective ASW, small attack boat barrier, or screen to the ESG. With maneuverability at high speed, the LCS-SUW is the platform of choice to beat the FAC/FIAC threat and can quickly delivery Marines for EMIO or coastal infiltration and extraction involving SOF. The large flight deck and LCS speed gives the commander numerous aircraft employment options for planning long-range air operations by acting as a “lily-pad” or sprinting ahead to recovery aircraft. The shallow draft allows the LCS to operate in littorals not

possible for a LPD or DDG. This makes the LCS an ideal platform for the Security Cooperation, MIO, Anti-piracy, or Anti-drug missions involving international partners whose navies are coastal patrol boats.

Due to the single-mission focus of its seaframe, two to three LCS ships would integrate with an ESG with mission packages “tailored” to complement the other strike group combatants. The Joint Task Force Commander (JTFC) would determine the “tailored” mission configurations of the LCS to meet his operational needs. With LCS limited endurance, especially at high speed, the LCS would need ready access to an MSC supply ship or port for refueling. The JHSV (see appendix M page 63) with large fuel storage and internal volume capacities could provide “mother-ship” logistic support to the LCS. LCS squadrons would offer collective mission flexibility and versatility while providing mutual support. The number of ships in an LCS squadron would be determined by the mission, but usually consist of two to three LCS seaframes and one JHSV. The squadrons would also pair both hull versions to take advantage of each seaframe design. The Lockheed version is the better design for small boat operations, while the General Dynamics model is better at conducting flight operations. The seaframes would be forward deployed but not forward based and maintain a continuous presence in critical littoral theaters of operation. A squadron would provide first response capability to an anti-access crisis, and when integrated with the ESG assets, could assist in executing access assurance. In limited independent operations or with a JHSV, the LCS with appropriate module package could fill the mobility mission in a known littoral threat environment while providing for rapid response to contingency mission tasking. It should be noted that while an individual LCS provides capability in singular missions, it is when the LCS operates in squadrons when the true effectiveness of this platform is realized. With modular multi-mission adaptability, high-speed

and shallow draft, the LCS gives the JTFC a flexible platform that accommodates changing tactical requirements while opening up a larger area of seaborne operations and meets USMC future operating concepts.

The latest *National Military Strategy* released in February 2011, identifies a dynamic distribution of power characterized by a “multi-nodal” world based on diplomatic, military and economic interest-driven coalitions. It will require a joint force that is globally available yet regionally focused. The strategy to shape future force capabilities concentrates on fielding modular, adaptive, and general-purpose forces that can be employed in the full range of military operations. That maritime force will include an appropriate mix of small, mission-tailored, and large multi-mission capable ships that can conduct the full range of naval operation across the spectrum of maritime environments. The LCS is that modular unit that is regionally focused and can adapt to a variety of missions to strengthen international and regional security to meet National Defense Strategy.<sup>86</sup>

## **APPENDIX A - Acronyms**

A2/AD - Anti-access/area-denial

ADS - Advanced Deployable System

ASCM - Anti-Ship Cruise Missile

ASW - Anti-submarine warfare

BMD - Ballistic missile defense

C4ISR - Command, control, communications, computer, intelligence, surveillance, and  
reconnaissance

CIWS - Close-in Weapon System

CNO - Chief of Naval Operations

CSG - Carrier Strike Group

DDG - Guided Missile destroyer

ESG - Expeditionary Strike Group

EOD - Explosive Ordinance and Disposal

FAC - Fast-Attack Craft

FIAC Fast Inshore Attack Craft

GFS - Global Fleet Station

HA/DR - Humanitarian assistance/disaster relief

IPOE - Intelligence preparation of the operational environment

ISR - Intelligence, surveillance, and reconnaissance

JHSV - Joint High Speed Vessel

LCS - Littoral Combat Ship

MCM - Mine Countermeasure

MIO - Maritime Interception Operation

MIW - Mine warfare

MPA - Maritime Patrol Aircraft

MSC - Military Sealift Command

MSO - Maritime Security Operation

NEO - Non-Combatant Evacuation Operation

NLOS - Non line of sight

NWDC - Naval Warfare Development Command

OTH - Over-the-Horizon

RAM - Rolling Airframe Missile

RHIB - Rigid-Hulled Inflatable Boat

RTAS - Remote Towed Active Source

SLOC - Sea lines of communication

SOF - Special Operations Forces

SSN - Nuclear-Powered Attack Submarine

SUW - Surface warfare

TALON - Tactical Littoral Ocean Network

TTP - Tactics, Techniques, and Procedures

UNREP - Underway replenishment

UAV - Unmanned aerial vehicle

USV - Unmanned surface vehicle

UUV - Unmanned underwater vehicle

VBSS - Vessel Boarding, Search, and Seizure

VLS - Vertical-launch system

VTUAV - Vertical Take-Off Tactical Unmanned Vehicle

## APPENDIX B – Chronology of LCS Development

- **2004**, Lockheed Martin, General Dynamics and Raytheon submitted designs to the Navy of their proposed littoral combat ships under a two ship competitive bid contract.
- **09 May 2005**, SECNAV Gordon R. England announces the first LCS name as USS *Freedom* (LCS-1) and second as USS *Independence* (LCS-2).
- **02 June 2005**, USS *Freedom* (LCS-1) keel laid down at Marinette Marine, Marinette, Wisconsin.
- **23 September 2006**, USS *Freedom* (LCS-1) christened and launched at the Marinette Marine shipyard.
- **19 January 2006**, the keel for the General Dynamics trimaran, USS *Independence* (LCS-2), laid at the Austal USA shipyards in Mobile, Alabama.
- **12 April 2007**, the Navy canceled the contract with Lockheed Martin for the construction of LCS-3 after negotiations to control cost overruns failed.
- **01 November 2007**, the second General Dynamics ship (LCS-4) cancelled. The Navy issues a new bidding process for the next three ships, with the winner building two ships and the loser only one.
- **30 April 2008** USS *Independence* (LCS-2) is launched.
- **08 November 2008**, the *Freedom* was commissioned in Veteran's Park, Milwaukee, Wisconsin.
- **March 2009**, Secretary of the Navy Donald C. Winter announced that LCS-3 would be named the USS *Fort Worth* (LCS-3) after Fort Worth, Texas and the fourth ship would be named the USS *Coronado* (LCS-4) after Coronado, California. The Navy renewed the contract with Lockheed to build its second LCS, the USS *Fort Worth* (LCS-3).
- **06 April 2009**, Secretary of Defense Robert Gates announced a Department of Defense budget that would purchase three LCS in FY '10 with a goal of 55 total ships.
- **01 May 2009**, the Navy renewed the contract with Austal/GD to build its second Trimaran LCS, the USS *Coronado* (LCS-4), with delivery scheduled for May 2012.
- **15 May 2009**, Navy Acquisition Chief, Sean Stackley said that the Navy had no current plans to down-select to a single design and senior Navy officials pointed out the two designs have complementary features.
- **30 June 2009**, Chief of Naval Operations Admiral Gary Roughead said that costs have nearly stabilized on the next batch of LCS vessels and that he would work with Congress to adjust the cost cap on these naval ships.
- **16 September 2009**, Navy acquisition chief Sean Stackley and Vice Admiral Barry McCullough said that only one of the contractors would be offered a fixed price contract in 2010 for up to ten ships. This would be the long rumored down-select to a single design. This would be followed in 2012 with an offer for a second shipyard to build up to five additional ships of the same design as the first



shipyard. Congress agreed to this plan. FY2010 budget documents revealed that the total costs of the two lead ships had risen to \$637 million for *Freedom* and \$704 million for *Independence*.

- **16 January 2010**, the *Independence* was commissioned in Mobile, Alabama.
- **04 March 2010**, Austal USA split from Bath Iron Works and announced that it would bid on future LCS contracts by itself; so that Austal could for example win the 2010 contract and Bath could win the follow on contract in 2012. The implication is Austal is no longer dependent on Bath Iron Works to bid for the contracts. Austal is more independent and has more financial control to determine costs for building subsequent hulls in their shipyard.
- **23 August 2010**, The US Navy announced a delay in awarding the contract for 10 ships until sometime near the end of the year.
- **November 2010**, The Navy reversed itself and asked Congress to allow the order of ten for each design, instead of just ten of one type. The Government Accountability Office identified problems with the designs other than shipbuilding. These include extremely long crew training times, unrealistic maintenance plans, and the lack of comprehensive risk assessment.
- **13 December 2010**, both production teams extended their current contract prices until December 30 in order to enable the Navy to push the procurements through Congress. The Navy has apparently budgeted \$490 million per ship for the 20 ships, while the Congressional Budget Office has projected a cost of \$591 million per ship. Navy acquisition chief Sean Stackley testified to a Senate panel that the actual price range was \$440 to \$460 million.
- **29 December 2010**, LM/Marinette Marine and GD/Austal USA received contracts to build 10 more Littoral Combat Ships (LCS) each for the U.S. Navy. The new contracts give each shipbuilding team one ship in 2010 and one each in 2011. Two more per year for each team will follow in 2012, 2013, 2014 and 2015. The contract for Lockheed's ship, the yet-to-be-named LCS 5, is for \$437 million. The contract for LCS 6, Austal USA's ship, is for \$432 million. The contract awards were announced one day before the prices were to expire.
- **29 December 2010**, the LCS program was now well within the Congressional cost cap of \$480 million per ship. The average per-ship target price for Lockheed ships is \$362 million with a goal of \$352 million for each Austal ship. Government-furnished equipment (GFE), such as weapons, add about \$25 million to each ship. All told, Stackley said, the average cost to buy an LCS should be between \$430 million and \$440 million.

**Source:** Ronald O'Rourke, "Navy Littoral Combat Ship (LCS) Program: Background, Issues, and Options for Congress," CRS RL33741, (Congressional Research Service (CRS), Washington, DC, November 29, 2010) , accessed February 21, 2011, <http://www.fas.org/sgp/crs/weapons/RL33741.pdf>.

For news release links: [http://en.wikipedia.org/wiki/Littoral\\_combat\\_ship#cite\\_ref-16](http://en.wikipedia.org/wiki/Littoral_combat_ship#cite_ref-16), accessed 21 February 2011.

## APPENDIX C – Design Specification

**Table 1 - Contractor Delivered LCS Design Specifications**

	<b>General Dynamics</b>	<b>Lockheed Martin</b>
	<u>Trimaran</u>	<u>Semi-Planing</u> Advanced steel monohull
Length	127.1 meters	115 meters (377 feet)
Beam	30.4 meters	Greater than 13 meters (42 feet) (waterline)
Draft	4.5 meters	Less than 4 meters (13 feet)
Full load displacement	2,800 tons	Less than 3000 metric tons
Sprint Speed (full load)	45 knots	45 knots
Top speed (light load)	45 knots	Greater than 50 knots
Range	4,500 NM	
Watercraft launch and recovery	Sea State 4	Sea State 4
Aircraft launch and recovery	Sea State 5	Sea State 5
Propulsion	<ul style="list-style-type: none"> <li>• 2 Gas Turbines</li> <li>• 2 Diesel Engines</li> <li>• 4 Steerable Waterjets</li> <li>• 1 Steerable Thruster</li> </ul>	<ul style="list-style-type: none"> <li>• Combined diesel and gas turbine</li> <li>• steerable water jet propulsion</li> </ul>
Armament / Mission Operations	<ul style="list-style-type: none"> <li>• Surface to Air Missile Launcher</li> <li>• 57 mm Gun</li> <li>• Minor Caliber Guns</li> <li>• <u>AN/WLD-1 Remote Minehunting System</u></li> <li>• Decoys and Countermeasures</li> </ul>	<ul style="list-style-type: none"> <li>• Rolling Airframe Missile</li> <li>• medium caliber gun</li> <li>• decoy launching system</li> <li>• <u>AN/WLD-1 Remote Minehunting System</u></li> <li>• Core self-defense suite</li> </ul>
Mission Operations	<ul style="list-style-type: none"> <li>• Air, Surface and Subsurface Sensors</li> <li>• Coordinated Air, Surface and Undersea Tactical Picture</li> <li>• Joint Force Tactical Coordination &amp; Interoperation</li> <li>• COTS / NDI Core Mission System</li> </ul>	<ul style="list-style-type: none"> <li>• EO/IR gunfire control system</li> <li>• Integrated bridge system Fully digital nautical charts are interfaced to ship sensors to support safe ship operation</li> <li>• 3D air search radar</li> </ul>
	<ul style="list-style-type: none"> <li>• Near-simultaneous air operations: 2 helicopters or multiple UAVs / VTUAVs</li> <li>• Hangar capable of housing two SH-60 helos</li> <li>• Flight deck capability one H-53 helo</li> <li>• Mission Bay Volume: 11,000 cubic meters</li> <li>• Side Mission Bay Access</li> <li>• Water Craft Stern Launch Capability</li> </ul>	<ul style="list-style-type: none"> <li>• Two H-60 helos or one H-60 helo and three VTUAVs</li> </ul>
Core crew	40	< 50; living spaces provide higher sailor quality of life than current fleet

**Table 2 - LCS Contractual Design Requirements**

Category	Threshold Level	Objective Level
Total Price per Ship	Meet CAIV target in the REP	Exceed CAIV target in the REP
Hull Service Life	20 Years	30 Years
Draft at Full load Displacement	20 feet	10 feet
Sprint Speed at Full Load Displacement in Sea State #	40 Knots in Sea State 3 (note 1)	50 Knots in Sea State 3 (note 1)
Range at Sprint Speed	1,000 nautical miles (note 2)	1,500 nautical miles (note 2)
Range at Economical Speed	3,500 nautical miles (>18 knots) with payload	4,300 nautical miles (20 knots) with payload
Aviation Support	Embark and hangar: one MH-60R/S and VTUAVs, and a flight deck capable of operating, fueling, reconfiguring, and supporting MH-60R/S/UAVs/NTUAVs	Embark and hangar: one MH-60R/S and VTUAVs, and a flight deck capable of operating, fueling, reconfiguring, and supporting MH-60R/S/UAVs/NTUAVs
Aircraft Launch/Recover	Sea State 4 best heading (note 1)	Sea State 5 best heading (note 1)
Watercraft Launch/Recover	Sea State 3 best heading with in 45 mins. (note 1)	Sea State 4 best heading with in 15 mins. (note 1)
Mission Package Boat type	11 Meter RHIB	40 ft High Speed Boat
Time for Mission Package Change-Out to full operational capability including system OPTEST	4 days	1 days
Provisions	336 hours (14 days)	504 hours (21 days)
Underway Replenishment Modes (UNREP)	CONREP VERTREP and RAS	CONREP VERTREP and RAS
Mission Module Payload (note 3)	180 MT (105 MT mission package / 75 MT mission package fuel)	210 MT (130 MT mission package / 80 MT mission package fuel)
Core Crew Size	50 Core Crew Members	15 Core Crew Members
Crew Accommodations (both core crew and mission package detachments)	75 personnel	75 personnel
Operational Availability (Ao)	0.85	0.95

- Note 1: Sea State parameters are defined (see Appendix L - Table 5, page 61.)
- Note 2: Includes Payload - Taking into account the focused mission nature of the LCS, payload is defined as the heaviest possible Mission Package and core mission systems, excluding ship's fuel.
- Note 3: Mission package payload is defined as all non-core systems, vehicles, helos, ordnance, and associated personnel, equipment, and containers to perform a single mission. This includes fuels to operate the mission package.
- **Source:** *LITTORAL COMBAT SHIP FLIGHT 0 PRELIMINARY DESIGN INTERIM REQUIREMENTS DOCUMENT (PD-IRD)*, February 10, 2003, accessed 21 February 2011, <http://www.globalsecurity.org/military/library/report/2003/03r2309-attach-j-4.pdf>

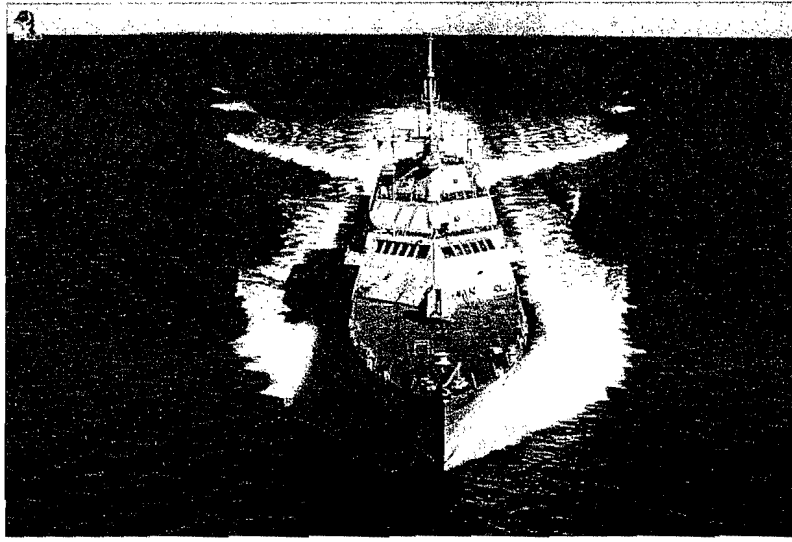
## AUSTRAL Joint High Speed Vessel (JHSV) Specifications

The JHSV is capable of transporting troops and their equipment, supporting humanitarian relief efforts, operating in shallow waters and reaching speeds in excess of 35 knots fully loaded. The vessels will be a joint-use platform between the United States Army and Navy.

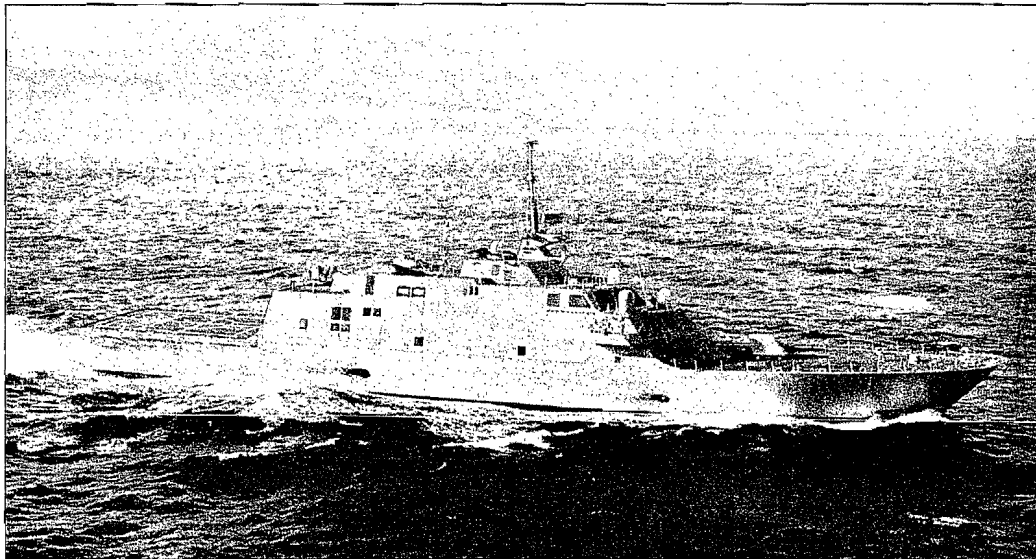
<b>Client:</b>	US Department of Defense
<b>Hull Number:</b>	630, 631, 632
<b>Hull Type:</b>	Catamaran
	This delivery is a work in progress.
<b>Length:</b>	103 metre
<b>Speed:</b>	More than 35 knots
<b>Draft :</b>	3.8m. Superior Draft for Austere Port Access
<b>Range :</b>	1200nm at 35knots
<b>Payload :</b>	635MT
<b>Crew Accommodations :</b>	Embarked troop berthing for 150 troops and airline style seating for 312 Troops at 5.25 ft seating pitch
<b>Aviation Capability :</b>	CH-53E capable flight deck
<b>Loading Ramp :</b>	Proven Austere Loading Ramp Arrangement. Supports M1A2 Abrams tanks
<b>Mission Deck :</b>	Open Unobstructed Mission Deck. Usable Cargo Area of more than 1800 m2 (Clear height of 4.75 m and turning diameter of 26.21 m)
<b>Fuel Consumption :</b>	Superior Fuel Efficiency to reduce operating costs. Proven MTU 8000 engines as used on LCS and Hawaii Superferry
<b>Motion Control :</b>	Superior Motion Characteristics. Active motion control system with 4 control surfaces

**Source:** Austal website: <http://www.austal.com/index.cfm?objectID=6B42CC62-65BF-EBC1-2E3E308BACC92365>, accessed 21 February 2011.

## APPENDIX D – USS *Freedom* LCS-1



**Figure 1 - USS *Freedom* LCS-1 – Monohull Bow Aspect**



**Figure 2 - USS *Freedom* LCS-1 – Beam Aspect**

**Source:** Lockheed Martin LCS Program Website: <http://www.lmlcsteam.com/> accessed 24 February 2011.

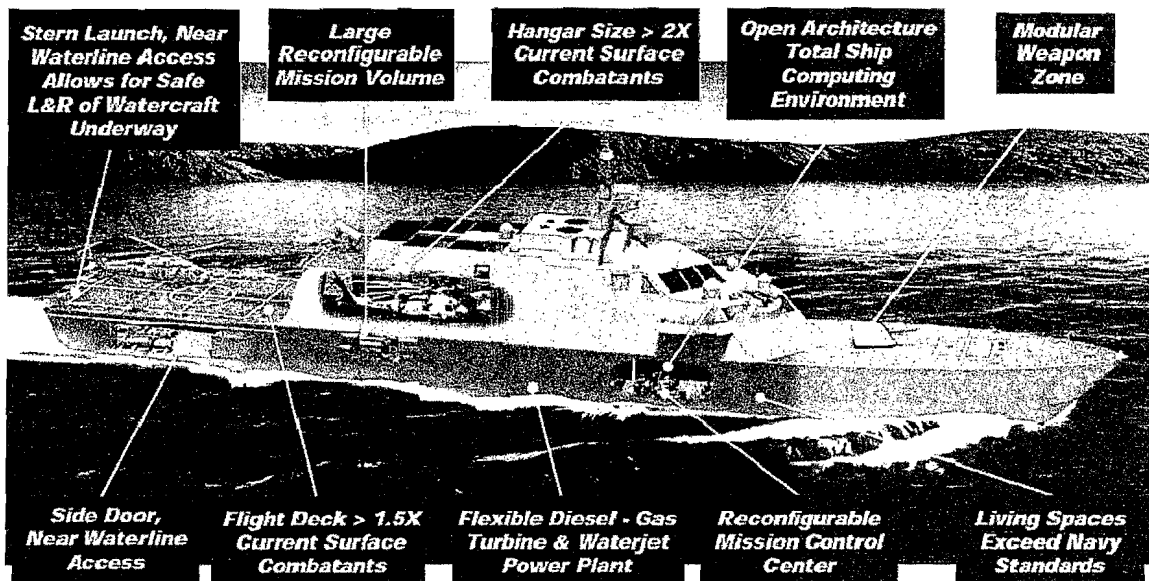
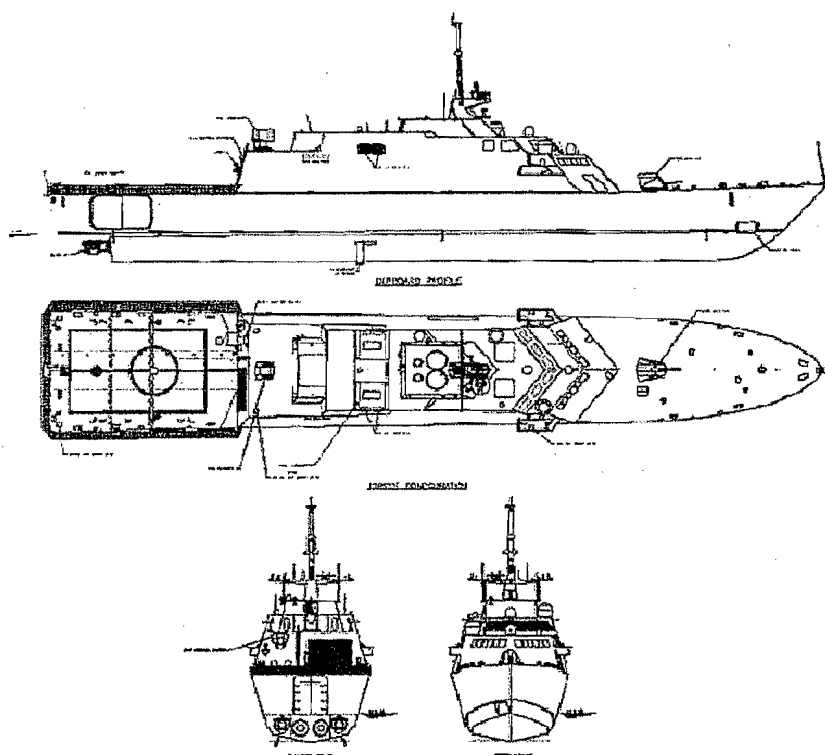


Figure 3: USS *Freedom* LCS-1 Design Highlights



#### PRINCIPAL CHARACTERISTICS

- LOA 115.3 m (378.3 ft)
- Beam 17.5 m (57.4 ft)
- Draft 3.9 m (12.8 ft)
- Displacement ~3000 MT

#### PROPULSION & ELECTRICAL - CODAG

- Gas Turbines 2
- Diesels 2
- Waterjets 4
- Diesel Generators 4

#### AVIATION FACILITIES

- Hangar for 1 MH - 60 (tail unfolded) + 3 VTUAV
- Flight Deck Area for 1 MH - 60

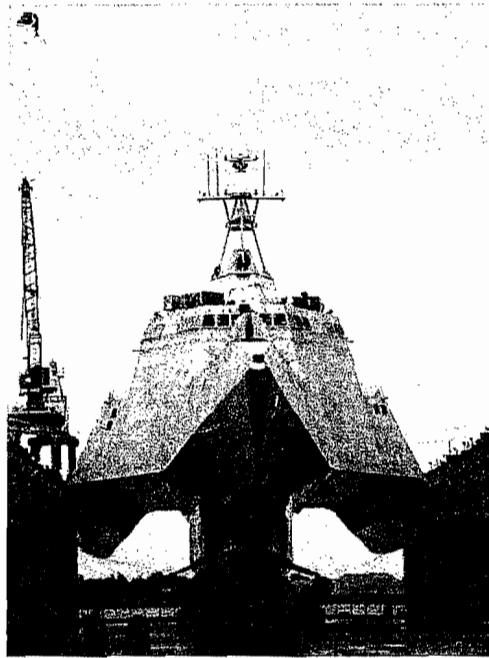
#### SPRINT SPEED

- 40 Kts

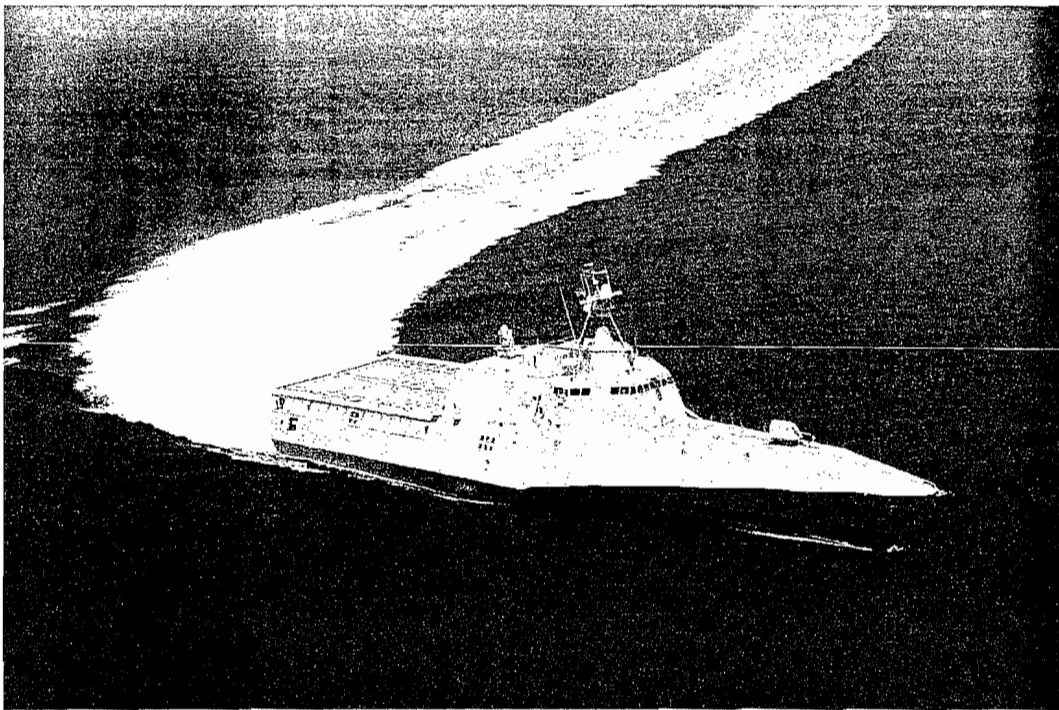
Figure 4: USS *Freedom* LCS-1 Schematics

**Source:** Bill Schoenster and Ken Michaud, "Navy Industry International Dialogue (NIID), Navy Littoral Ships, US Navy, USCG and International Navy Views," 06 November 2008, accessed 24 February 2011, [http://www.ndia.org/Divisions/Divisions/International/Documents/International\\_LCS\\_Program\\_Overview.pdf](http://www.ndia.org/Divisions/Divisions/International/Documents/International_LCS_Program_Overview.pdf).

## APPENDIX E – USS *Independence* LCS-2



**Figure 5 - USS *Independence* LCS-2 – Trimaran Bow Aspect**

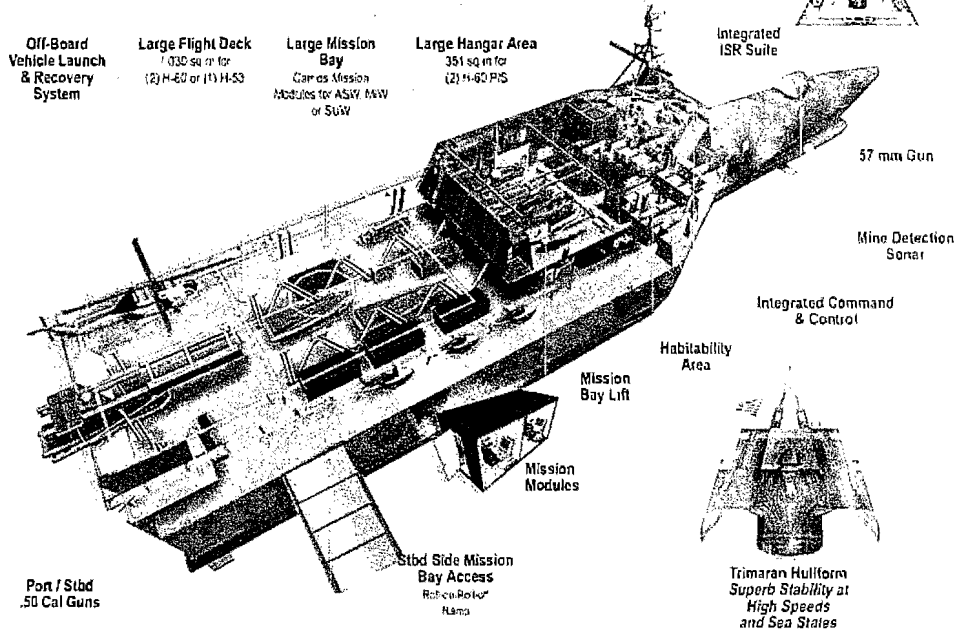


**Figure 6 - USS *Independence* LCS-2 – Beam Aspect**

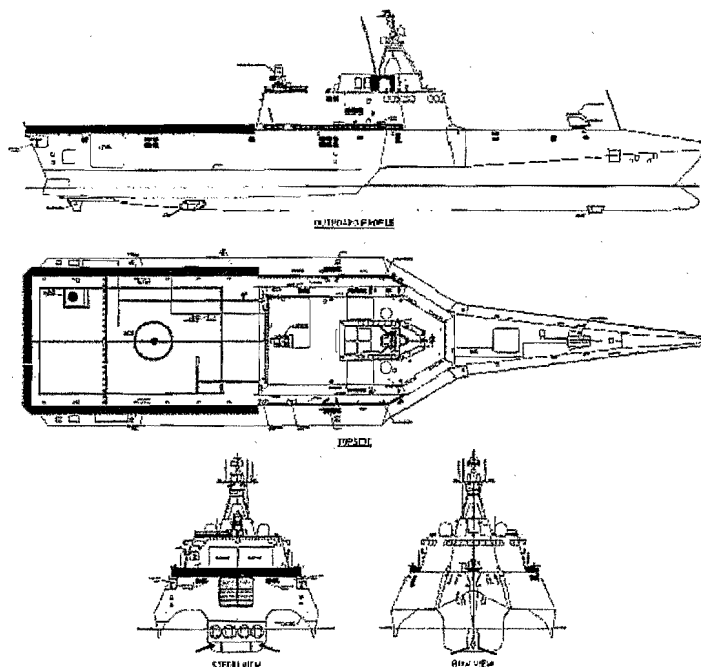
**Source:** General Dynamics LCS program Website: <http://www.gdlcs.com/> accessed 24 February 2011.

**GENERAL DYNAMICS**  
Littoral Combat Ship

**Maximum Warfighting Capability Per Dollar**



**Figure 7: USS Independence LCS-2 Highlights**



**PRINCIPAL CHARACTERISTICS**

- LOA 127.6 m (418.6 ft)
- Beam 31.6 m (103.7 ft)
- Draft 4.3 m (14.1 ft)
- Displacement ~3000 MT

**PROPULSION & ELECTRICAL-CODAG**

- Gas Turbines 2
- Diesels 2
- Waterjets 4
- Retractable Azi Thruster 1
- Diesel Generators 4

**AVIATION FACILITIES**

- Hangar for 2 MH-60 R/S
- Flight Deck Area for 2 MH-60

**SPRINT SPEED**

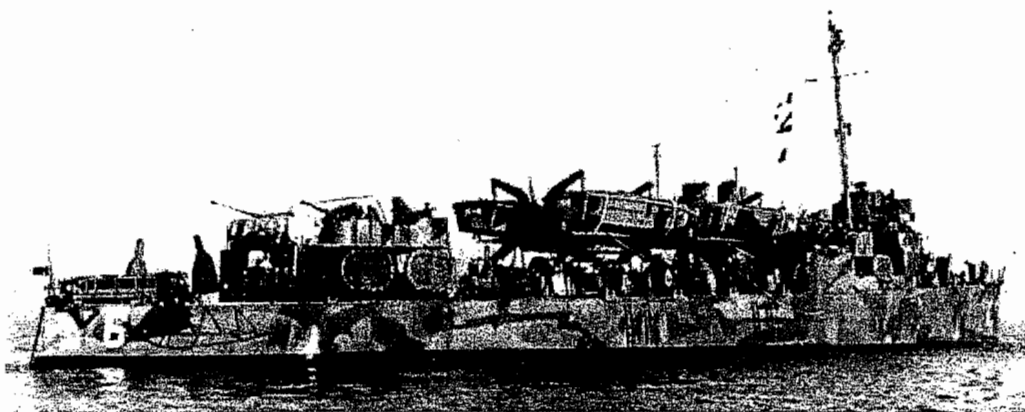
- 40 kts

**Figure 8: USS Independence LCS-2 Core Capabilities**

Source: Bill Schoenster and Ken Michaud, "Navy Industry International Dialogue (NIID), Navy Littoral Ships, US Navy, USCG and International Navy Views," 06 November 2008, accessed 24 February 2011, [http://www.ndia.org/Divisions/Divisions/International/Documents/International\\_LCS\\_Program\\_Overview.pdf](http://www.ndia.org/Divisions/Divisions/International/Documents/International_LCS_Program_Overview.pdf).



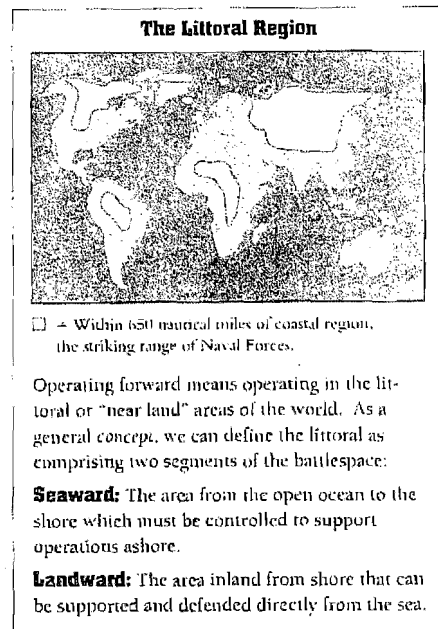
## Appendix F – USS *Stringham* APD-6: The First Marine-Carrying LCS



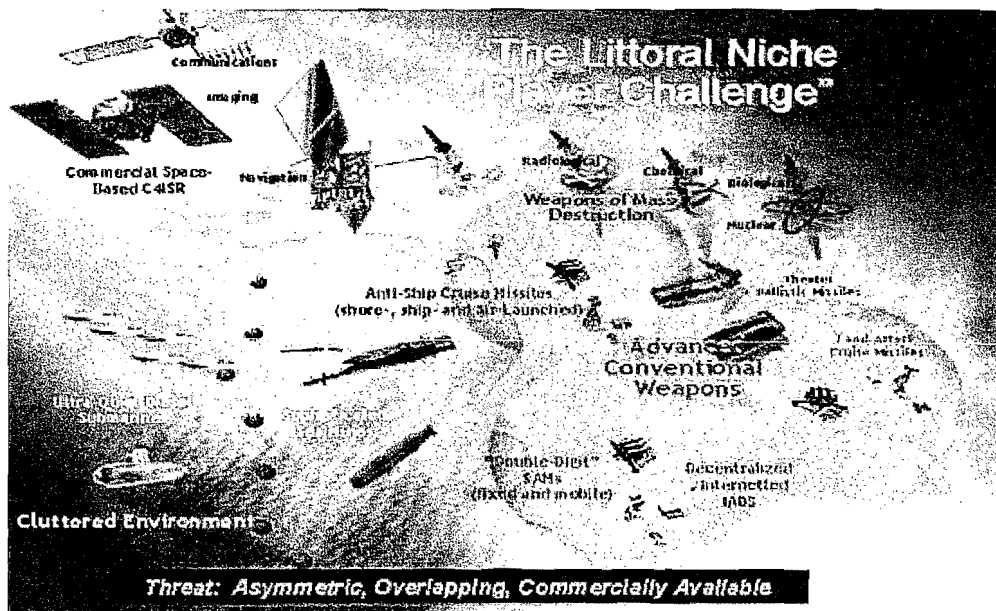
**Figure 9 - USS *Stringham* APD-6, was a fast transport from WWII, converted from a 4-stacker destroyer.**

**Source:** "Destroyer history," Destroyer History.org, accessed February 21, 2011, <http://www.destroyerhistory.org/flushdeck/apd.html>

## Appendix G – The Littoral Region

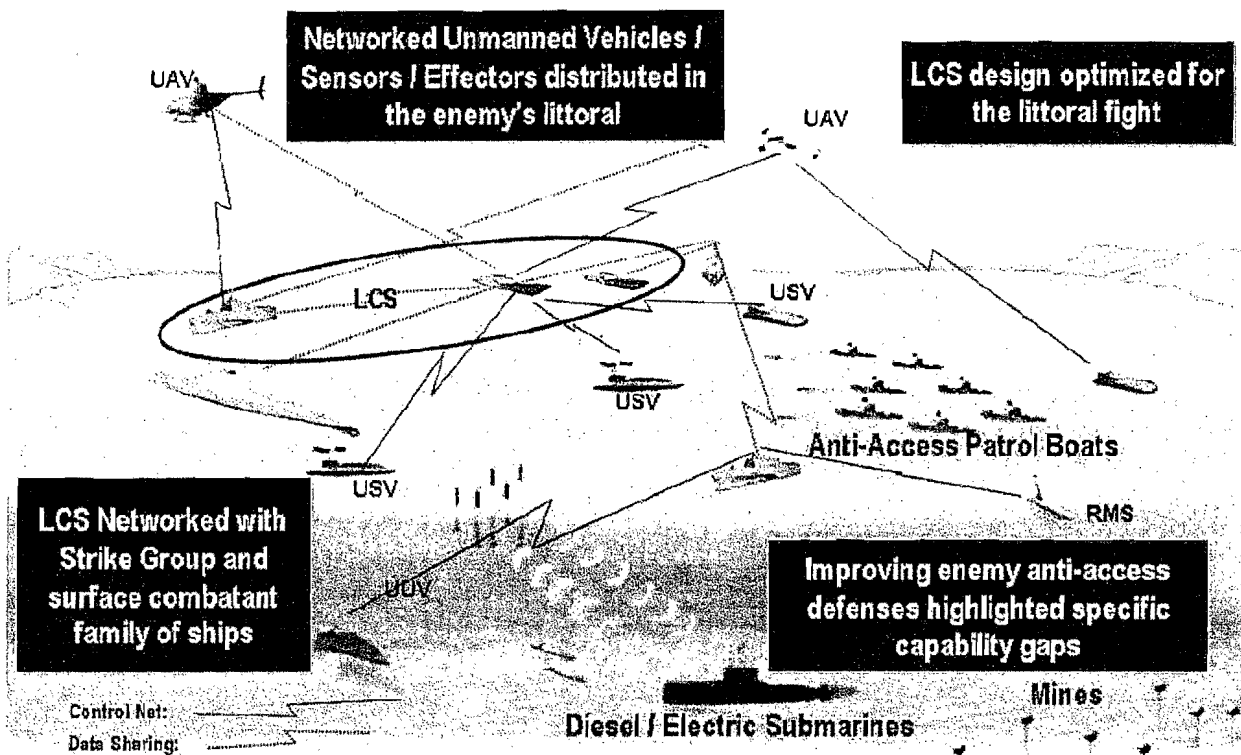


**Figure 10: The Littoral Region**  
Source: "...From The Sea," May 1992, 6.



**Figure 11: The Littoral Challenge**

Source: 10-11 JAN 2006 LCS Concept of Operations presentation to CNO,  
<http://faculty.nps.edu/jekline/docs/LCS%20CONOPS%20brief%2011-15pt1.ppt>, accessed 24 February 2011.



**Figure 12: LCS Concept of Operations in the Littorals**

**Source:** Bill Schoenster and Ken Michaud, "Navy Industry International Dialogue (NIID), Navy Littoral Ships, US Navy, USCG and International Navy Views," 06 November 2008, accessed 24 February 2011, [http://www.ndia.org/Divisions/Divisions/International/Documents/International\\_LCS\\_Program\\_Overview.pdf](http://www.ndia.org/Divisions/Divisions/International/Documents/International_LCS_Program_Overview.pdf).

## APPENDIX H – Mine Warfare Module

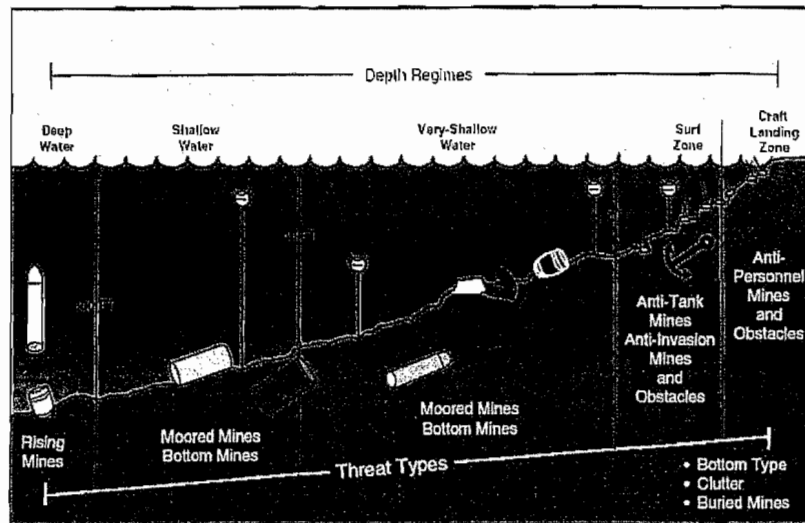


Figure 13 – Mine deployments

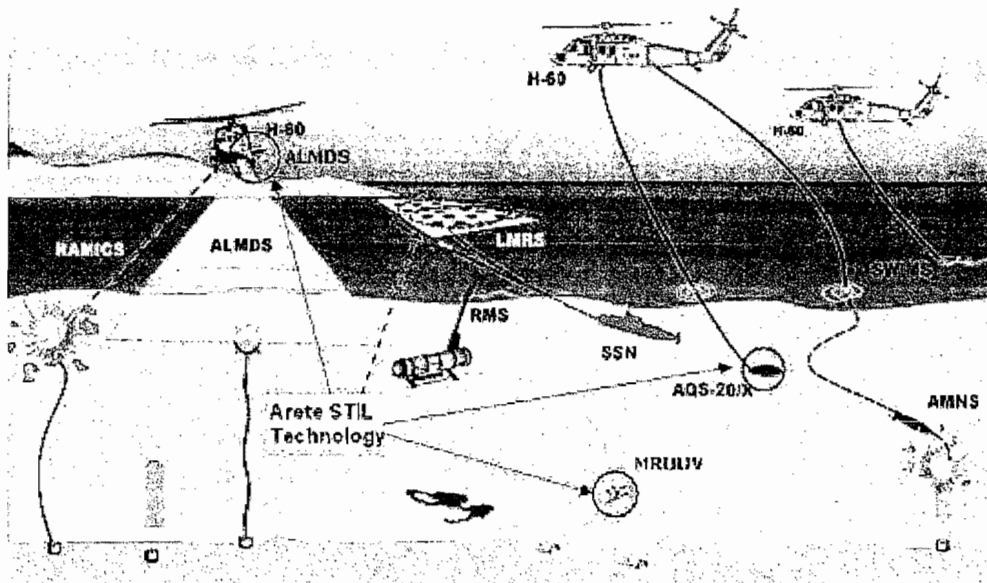


Figure 14: MIW Employment

**Source:** United States General Accounting Office, 2001, Improved littoral war-fighting capabilities needed. GAO-01-493.

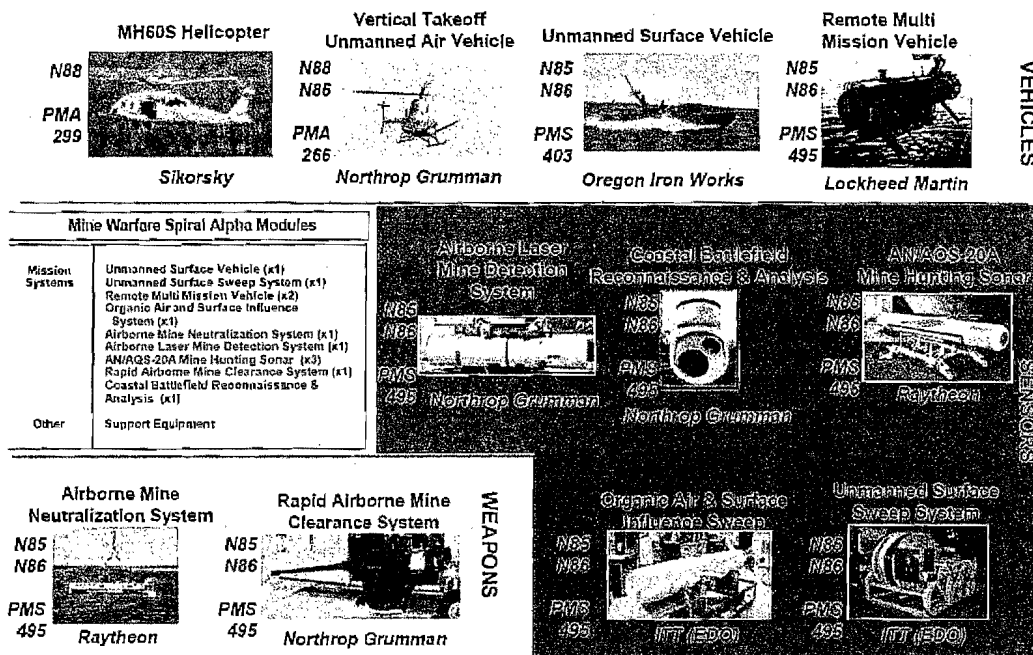


Figure 15: MIW Mission Package

**Source:** Bill Schoenster and Ken Michaud, "Navy Industry International Dialogue (NIID), Navy Littoral Ships, US Navy, USCG and International Navy Views," 06 November 2008, accessed 24 February 2011, <http://www.ndia.org/Divisions/Divisions/International/Documents/International LCS Program Overview w.pdf>

Mine Warfare Mission Package. The Mine Warfare package has the AN/WLD-1 remote minehunting system, AN/AQS-20A sonar mine detecting set, organic airborne surface influence sweep, airborne laser mine detection system, and airborne mine neutralization system. The RAMICS interfaces with the Mk46 Mod 1 30mm gun system for mine clearance. The MCM package elements (Fleet Forces Command, 2009) include:

<u>MIW Package Elements</u>	<u>QTY</u>
1) <u>Spartan Unmanned Surface Vehicle (USV)</u>	1
2) <u>RQ-8B Fire Scout helicopter VTUAVs</u>	1
a) Coastal Battlefield Reconnaissance and Analysis (COBRA)	2
3) <u>MH-60S Airborne Mine Countermeasures (AMCM)</u>	1
a) MH-60S helo	1
b) Organic Airborne and Surface Influence Sweep (OASIS)	1
c) <u>AN/AQS-20A Minehunting Sonar Set (helicopter-configured)</u>	1
d) Airborne Laser Mine Detection System (AES-1 ALMDS)	1
e) Rapid Airborne Mine Clearance System (RAMICS)	1
f) Airborne Mine Neutralization System (AMNS)	1
4) <u>AN/WLD-1 Remote Minehunting UUV System</u>	2

- 5) AN/AQS-20A Minehunting Sonar Set (RMV-configured) 2
- 6) The Command Center will include C4ISR, GCCS-M / MEDAL, NMWS and SIPRNET connectivity to enable the full range of MIWC command functions including reach-back to enable network centric operations. 1

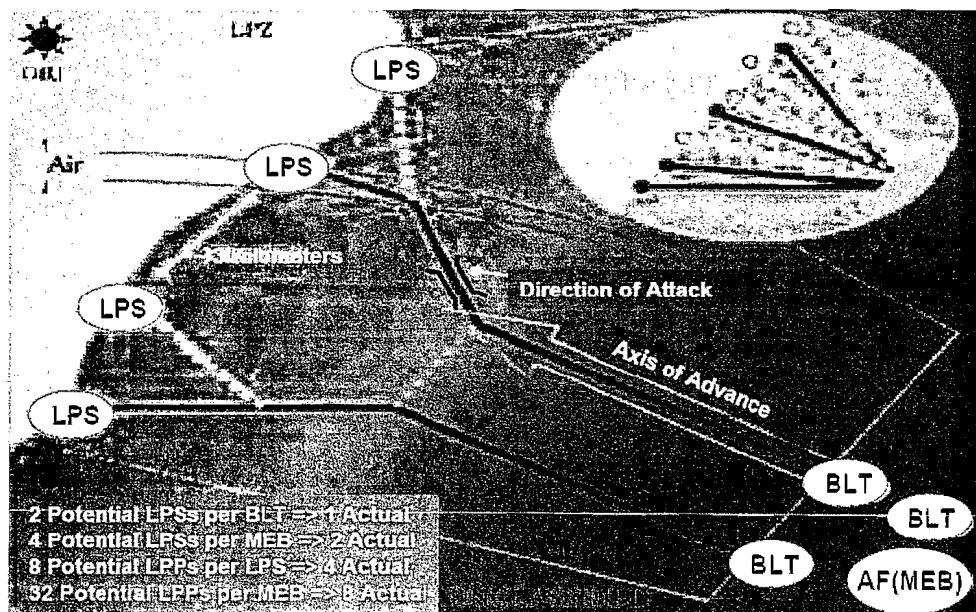
The MH-60 will be fitted with the AES-1 Airborne Laser Mine-Detection System (ALMDS), the Rapid Airborne Mine-Clearance System (RAMICS) with the 30mm cannon and “supercavitating” ammunition, the Airborne Mine-Neutralization System (AMNS), an AQS-20X sonar, and the organic airborne and surface influence sweep (OASIS) system. The AN/WLD-1 Remote Minehunting UUV System can be configured to tow the AN/AQS-20A towed mine-detecting sonar and sensors. The Spartan Scout USV is an 11m RHIB capable of handling a 5000 lb payload.

The AQS-20A airborne mine-detection sonar is used for rapid minefield reconnaissance and detection, localization, and classification of bottom, close-tethered, and volume mines. The Airborne Laser Mine-Detection System is an electro-optic system that provides rapid and cost-effective detection, classification, and localization of floating and near-surface moored sea mines. It is the first new mine-hunting technology delivered for US Navy fleet use since the introduction of sonar.

The AMNS is a remotely operated expendable neutralization device that is used by helicopters to neutralize--with explosives--moored and volume sea mines that are impractical or unsafe to counter through existing mine-disposal techniques. The AMNS is flown to the mine location, where it will deploy its expendable neutralization vehicle to reacquire the target and emplace a self-contained bulk or shaped charge at the most effective position to neutralize the threat mine.

The OASIS is a self-contained system designed to carry out high-speed magnetic or magnetic/acoustic influence minesweeping missions in shallow waters. It consists of a towed

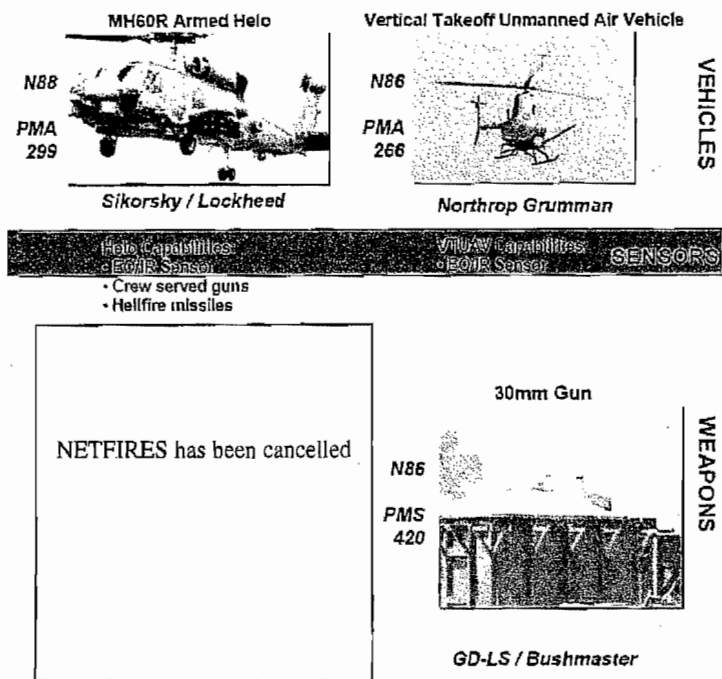
magnetic and acoustic source, a tow/power delivery cable, a power conditioning-and-control subsystem, and an external or palletized power supply. Capable of tow speeds of up to 40 knots—which provides for a large area-coverage rate—and transported by helicopter, OASIS allows for fast transit to over-the-horizon operating areas. The system's magnetic component is ten feet long, 20 inches in diameter, and weighs approximately 1,000 pounds. OASIS deploys from a helicopter using a standard tow cable after reaching the area of operation and interfaces with current and future acoustic sweeping devices.



**Figure 16: NTTP 3-15.3 MCM in Support of Amphibious Operations**

**Source:** Robert B. Neller, Brigadier General, USMC, "Power Projection Requirements: Naval Mine," (Brief presented for the Mine Warfare Association, Panama City, FL, May 24, 2005), accessed February 23, 2011, [http://www.minwara.org/Meetings/2005\\_05/Proceedings/7-MINWARA%2024%20May%2005%20change%202.pdf](http://www.minwara.org/Meetings/2005_05/Proceedings/7-MINWARA%2024%20May%2005%20change%202.pdf).

## APPENDIX I – Surface Warfare Module



**Figure 17: SUW Mission Package**

**Source:** Bill Schoenster and Ken Michaud, "Navy Industry International Dialogue (NIID), Navy Littoral Ships, US Navy, USCG and International Navy Views," 06 November 2008, accessed 24 February 2011, <http://www.ndia.org/Divisions/Divisions/International/Documents/International LCS Program Overview.pdf>

**Surface Warfare – Mission Package.** The SUW module includes two General Dynamics' Mk46 30mm cannons (also used in the Rapid Airborne Mine Clearance System), which fire at up to 200 rounds a minute at a range of 2200 yards. The seaframe mounted 57-mm Mk 110 fires automatic salvos at up to 220 rounds per minute to a maximum range of 17000m, and provides extreme pointing accuracy even in high sea-state conditions. The MH-60R is armed with guns and Hellfire missiles. The SUW package elements (Fleet Forces Command, 2009) include:

<u>SUW Modular Elements</u>	<u>QTY</u>
1) <u>RQ-8B Fire Scout helicopter (VTUAV)</u>	2
a) EO/IR/LD sensor and datalink relay	1
2) <u>MH-60R/S helicopters</u>	1
a) GAU 16/19 machine gun	1 (60R) or 2 (60S)
b) <u>AGM-114 Hellfire missiles</u>	8
3) <u>Mk 46 Mod 1 30mm gun system</u>	2



The Northrop Grumman's RQ-8B Fire Scout helicopter VTUAVs system is used afloat by Navy units and ashore by USMC units and to provide local commanders near-real time imagery and data to support Intelligence Surveillance and Reconnaissance (ISR) requirements. The vehicle has endurance greater than six hours with a 600 lb payload. It can loiter for more than four hours at a combat radius of 110nm while providing over-the-horizon targeting data.

The MH-60R helicopter carries the a .50 caliber GAU 16/A machine gun, a crew-served, recoil operated, belt-fed, air cooled, percussion fired weapon, with a rate of fire of 750 rounds per minute or the GAU 19, a GAU 16 that is electrically-driven. The helicopter can also carry the AGM-114 hellfire missiles with 500m to 8000m employment range with rate-of-fire of one missile every two seconds.

#### Recommended Additions / Modifications to improve the Surface Warfare Module.

The fire support for Marine EMIO and SOF operations will be improved by installing the following available and cost effective weapon systems to the Sea Scout, Spartan, or MH-60R. The weapon installations will also provide more firepower to engage and defeat FAC/FIAC threats.

1. The RQ-8B fitted with stub wings could be used to install weapons such as Hellfire missiles, Viper Strike<sup>87</sup> laser-guided glide weapons, and in particular pods carrying the Advanced Precision Kill Weapon System (APKWS)<sup>88</sup>, a laser-guided 70 millimeter (2.75 inch) folding-fin rocket.
2. Install a Griffin missile system on the RQ-8B Fire Scout helicopter (VTUAV)<sup>89</sup> and Spartan Unmanned Surface Vehicle (USV).

- a. The 33 pound, 42 inch long Griffin B<sup>90</sup> has a 13-pound blast-fragmentation warhead, and uses a combination GPS/INS and semi-active laser seeker. Estimated Griffin B range is in the Hellfire class, or about 5.5 km when ground-launched and 15.5 km when air-launched. A platform could carry three *Griffin* missiles in place of a single larger AGM-114 Hellfire.<sup>91</sup> Griffins would be extremely capable for engaging large number of enemy speedboats.
3. Upgrade the existing MH-60R GAUs and LCS .50 caliber M2HB mounts to the GAU-21 0.50" (12.7 mm) M3M FN Herstal MG.<sup>92</sup>
  - a. The M3M has only a third as much non-compensated recoil and a significantly longer barrel life. The range is 2000m with 1100 rounds per minute firing rate.
4. Install the M134D Gatling Gun on the Spartan USV and RQ-8B Fire Scout helicopter (VTUAV) in conjunction with the Griffin missile system or as an interchangeable, independent kit.
  - a. The M134 is a 7.62 mm, six-barreled, non-recoiling, electrically powered Gatling gun with firing rate of 3000 rounds per minute available in 1500, 3000 or 4400 round capacities. M134 is a modular system and can adapt to any existing platform and perform in the fixed-forward-fire or crew-served mode. Simple to load and easy to maintain, the M134 is considered one of the most reliable weapons in the world with an average of 30,000 rounds between stoppages. The M134 can achieve the extreme shot density needed to suppress multiple targets in compressed periods.<sup>93</sup> The Singapore Navy has operated a 7.62-mm caliber gun called a mini-Typhoon (Mk 49 Mod 0) installed on a Protector USV in Iraqi waters.<sup>94</sup>

5. Both LCS variants lack surface-to-surface or air-to-surface missiles to engage larger warships without support from the ESG. The installation of the Israeli Delilah<sup>95</sup> missile launcher on the seaframe (Delilah-SL) and SH-60 helicopter (Delilah-HL) would correct this vulnerability and make the LCS more capable on an independent deployment.

- a. The combat proven Delilah is an advanced electro-optically guided, stand-off weapon system, designed to provide unique precision strike capabilities against high value, re-locatable and time critical targets. Israeli Military Industries and the Israeli Air Force have developed Delilah to meet the most challenging requirements of strike missions by offering unique capabilities including “pull-up,” “go-around” and “re-attack” capabilities, derived from the weapon’s extended range and loitering capability. Delilah allows the Launching Aircraft to remain outside of the lethal envelope of modern Medium and Long Range Surface to Air Missiles (SAM), providing aircrews with effective, high precision, man-in-the-loop stand-off strike capability. Flying deep into the enemy territory, as far as 250 Km, the weapon relies on sophisticated, on-board flight control and navigation systems providing fully autonomous navigation and flight handling.

- i. Specifications:

- Payload: 66 lb conventional warhead

- Dimensions: weight 550lbs, 250 kilograms (550 lb), length 3.31m (10.9 ft),  
diameter 0.33 m (1 ft 1 in), wingspan 1.15 m (3 ft 9 in)

- Operational range: 250 km (160 mi)

- Flight altitude: 28,000 feet (8,500 m)

- Speed: Mach 0.3-0.7 (Dive: Mach 0.85)

Guidance system: CCD\IR with GPS\INS Accuracy 1 metre (3 ft 3 in) CEP

Launch platform: aircraft, helicopter, ground launcher, sea launcher.

## APPENDIX J – Anti-Submarine Warfare

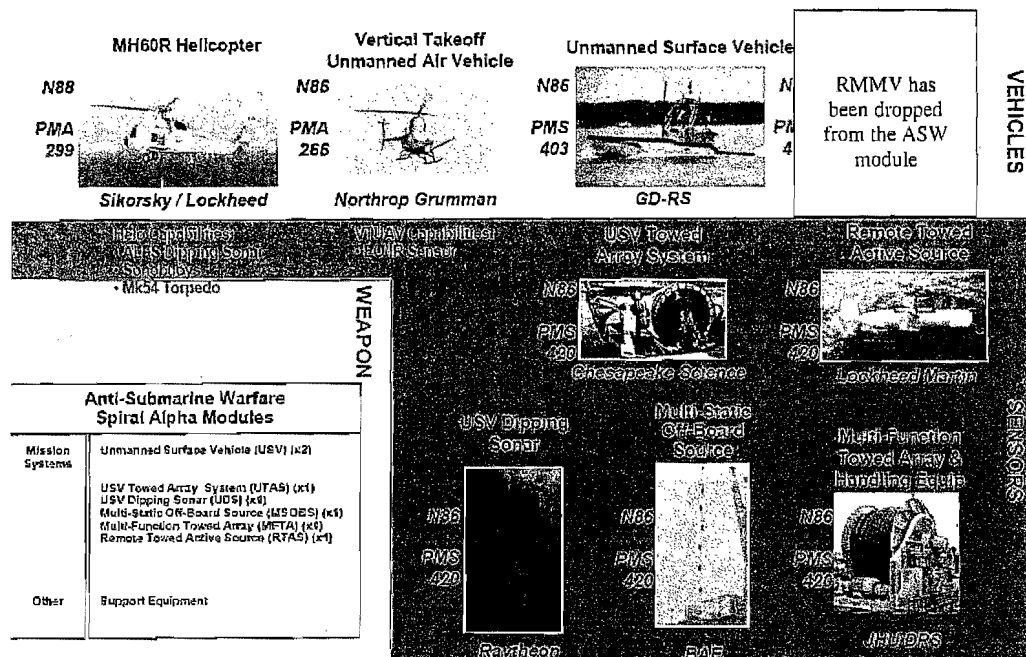


Figure 18: ASW Mission Package

**Source:** Bill Schoenster and Ken Michaud, "Navy Industry International Dialogue (NIID), Navy Littoral Ships, US Navy, USCG and International Navy Views," 06 November 2008, accessed 24 February 2011, [http://www.ndia.org/Divisions/Divisions/International/Documents/International\\_LCS\\_Program\\_Overview.pdf](http://www.ndia.org/Divisions/Divisions/International/Documents/International_LCS_Program_Overview.pdf)

Anti-Submarine Warfare – Mission Package. The unmanned vehicles and helicopters deployed by LCS are equipped with a variety of weapons, sensors - including active/passive dipping sonar, sonobuoys, torpedoes and various mobile and fixed sonar arrays. A communication suite networks the LCS, vehicles, and sensors. The ASW package elements (Fleet Forces Command, 2009) include:

ASW Modules	QTY
1) <u>MH-60R/S helicopters</u> with:	1
a. Raytheon <u>Mk 54 Torpedo Set</u>	1
b. AN/AQS-22 airborne low-frequency sonar set (ALFS)	1
c. Sonobouy set	1
2) <u>Spartan</u> unmanned Surface Vehicle (USV) with ASW Systems:	2
a. USV dipping Sonar (UDS)	2
b. <u>Sea TALON (Tactical Littoral Ocean Network):</u>	2
i. <u>AN/SQR-20 Multi-Function Towed Array (MFTA)</u>	2

ii. Remote Towed Active Source (RTAS)	2
3) <u>RQ-8B Fire Scout helicopter (VTUAV)</u> with:	1
a. EO/IR Sensor	1

Note 1: Advanced Deployable System (ADS) has been cancelled.

Note 2: Lockheed's WLD-1 sub-surface USV towing the AN/AQS-20A was to be part of the ASW module but was relegated to MIW only in late 2009. Source: Advanced Deployable system (ADS) for ASW has been cancelled, from <http://www.defenseindustrydaily.com/the-usas-new-littoral-combat-ships-updated-01343/>

The Lockheed Martin's Sea TALON (Tactical Littoral Ocean Network) system uses a Remote Towed Active Source (RTAS), a multi-band transducer networked with a Remote Towed Array (RTA), to provide search, detection, and localization of quiet submarines in the littorals. An unmanned, semi-autonomous, surface vehicle by General Dynamics called Spartan (USV) tows each array. The Spartan USV is equipped with dipping sonar and is launched and controlled remotely from a LCS. Lockheed's AN/SQR-20 Multi-Function Towed Array (MFTA) is a passive and active sonar receiver configured as a long three-inch diameter array that can be towed behind the USV. The MH-60R/S helicopter is equipped with an Mk54 torpedo set, sonobuoys and Raytheon's AN/AQS-22 airborne low-frequency sonar (ALFS).

#### Recommended Additions / Modifications to improve the Anti-Submarine Warfare Module.

1. The future "Sea Sparker" active sonobuoy designed for littoral application should be added. The Sparker is a part of the Tactical Acoustic Measurement and Decision Aid (TAMDA) environmental sonobuoy that collects, processes, and transmits acoustic data required by the US Navy to enhance anti-submarine warfare operations in shallow water.
2. Install a small, side-mounted, high-frequency active hull sonar on the LCS seaframe for mine avoidance and torpedo detection similar to the US Navy Patrol Coastal Cyclone class Bobcat sonar. The ship while operating mainly in the littoral is vulnerable to torpedo attacks from quiet AIP and on-battery diesel submarines.

Recommended Addition / Modification to improve the LCS seaframe's Anti-Submarine defense:

Torpedo Countermeasures. Although not in the Preliminary Design Interim Requirements Document (PD-IRD), a significant LCS vulnerability is the lack of torpedo countermeasures for self-defense in the littorals. The installation of the Mk-32 Surface Vessel Torpedo Tube<sup>96</sup> (SVTT) (or equivalent) launchers equipped with Mk46 or Mk-50 torpedoes could provide a cost effective installation. The Mk-32 SVTT is capable of storing and pneumatically firing up to three Mk-46 or Mk-50 torpedoes over-the-side of a surface ship. The SVTT launches torpedoes under local control or remote control from an ASW fire control system.

1. The MK-46 torpedo is designed to attack high performance submarines, and is presently identified as the NATO standard. The MK-46 Mod 5 torpedo is the backbone of the Navy's lightweight ASW torpedo inventory and is expected to remain in service until the year 2015.

- a. General Characteristics of the MK-46 MOD 5:

Primary Function: Air and ship-launched lightweight torpedo

Contractor: Alliant Techsystems

Power Plant: Two-speed, reciprocating external combustion; Mono-propellant  
(Otto fuel II) fueled

Length: 102.36 in. tube launch configuration (from ship)

Weight: 517.65 lbs (warshot configuration)

Diameter: 12.75 inches

Range: 8,000 yards

Depth: Greater than 1,200 ft (365.76 meters)

Speed: Greater than 28 knots (32.2 mph, 51.52 kph)

Guidance System: Homing mode - Active or passive/active acoustic homing

Launch/search mode: Snake or circle search

Warhead: 98 lbs. of PBXN-103 high explosive (bulk-charge)

Date Deployed: 1966 (Mod 0); 1979 (Mod 5)

2. The MK-50 is an advanced lightweight torpedo for use against the faster, deeper-diving and more sophisticated submarines. The MK-50 can be launched from all ASW aircraft, and from torpedo tubes aboard surface combatant ships. The MK-50 will eventually replace the MK-46 as the fleet's lightweight torpedo.

- a. General Characteristics of the MK-50:

Primary Function: Air and ship-launched lightweight torpedo

Contractor: Alliant Techsystems, Westinghouse

Power Plant: Stored Chemical Energy Propulsion System

Length: 112 inches

Weight: 750 pounds

Diameter: 12.75 inches

Speed: 40+ knots

Guidance System: Active/passive acoustic homing

Warhead: Approximately 100 pounds high explosive (shaped charge)

The Mk-46 and Mk-50 can also be employed as an effective countermeasure against attacking torpedoes.<sup>97</sup>



## APPENDIX K – Possible Additional Missions

In addition to the three focused core missions, the LCS will have an array of inherent capabilities with mission modules to support other taskings associated with Ocean Escort, Special Operation Forces (SOF), Joint Littoral Mobility, Scout - ISR, Anti-piracy/drug patrols, Security Cooperation, Combat Search and Rescue (CSAR), Special Operations Forces support, Maritime Interdiction Operations and Homeland Defense/Anti-Terrorism/Force Protection.

Ocean Escort. The LCS is not designed for an ocean-escort role in air, surface, or subsurface defense of the ESG. The LCS could provide a cheaper escort platform than the DDG by using the GD or LM multi-mission LCS variants while the DDG could focus on the future Ballistic Missile Defense (BMD) mission. The multi-mission hulls do not allow for full mission package integration due to space and weight-buoyancy constraints, but allow for Sea Scout and MH-60R helicopter operations.

The Navy's expeditionary forces are deploying to fulfill a variety of missions in the littorals at an escalating rate. The 2003 Marine Corps Gazette article by Rear Admiral Len Picotte and Commander Thomas Holmes<sup>98</sup> showed an increase of over 330% in total ESG employment days from 1980 through 1999:

Operation (duration in days)	Contingency Response	NEO	Disaster Relief	Humanitarian Assistance	Combat Action	Peacekeeping /Enforcement	Other	Total
Duration (1980's)	1493	76	74	16	23	324	569	2575
Duration (1990's)	1972	673	167	4045	235	2489	31	8612

With the new ESG employment concept evolved from the *Sea Power 21*, DDGs now accompany the amphibious ships to increase the strike capability of the force. The DDGs also provide force protection against the littoral threats but are limited from closing to the beach with the amphibious ships due to a navigational draft constraint of 36 feet. The DDGs, designed as deep-ocean assets to protect Carrier Strike Groups (CSG), are not optimized to conduct littoral

missions against FAC/FIAC, mines and coastal diesel submarines. These greater ESG escort operations decrease the availability of DDGs for the new BMD deployment requirements. Consequently, the DDG class is operating at an ever-higher rate to meet all these force demands. The LCS alleviates those demands by filling the DDG job in the littorals with two limitations. While the LCS can protect the ESG against enemy ASCMs, it lacks the capability to attack large enemy combatants with ASCMs. Additionally, the LCS cannot fill the area air defense role of the SPY radar, SM-2 missile equipped DDG, unless the GD or LM multi-mission LCS reference below was procured. Another option to give the LCS an ASCM capability would be to install a Delilah missile launcher on the seaframe as referenced in appendix (I) on page 45.

1. GD – offers a General Dynamics Multi-Mission Combatant<sup>99</sup> (GDMMC) that includes 32 “tactical-length” vertical launch cells (16-cell module on port and starboard) that are limited to shorter weapons like Evolved Sea Sparrow Missile (ESSM)<sup>100</sup> and SM-2 Block 3B<sup>101</sup> long-range air defense missiles, and Vertical Launched Anti-submarine rocket<sup>102</sup> (VL-ASROC) anti-submarine missiles. The variant also includes three ASW torpedoes in two SVTT launchers, eight Boeing RGM-84G Block 1G Harpoon<sup>103</sup> Surface to Surface Missile (SSM) in two quad-pack canister launchers, one 57 mm gun forward and 2 Close-in Weapons system (CIWS) 1B<sup>104</sup> mounts (port and starboard).<sup>105</sup>
2. LM – offers a Lockheed Martin Surface Combatant Ship<sup>106</sup> (LMSCS) a multi-mission hull with SPY-1F (V) radar<sup>107</sup> and the MK 41 Vertical Launching System<sup>108</sup> full strike-length cells that carries the SM-2 Block 3B or SM-3 air defense and Tomahawk precision attack missiles<sup>109</sup>, one CIWS and one 57 mm gun forward.<sup>110</sup> Install the Israeli Delilah Missile launcher on the seaframe for SSM capability. See appendix (I) on page 45 for information on the Delilah.

Special Operation Support. The LCS has the capability to embark two 11-meter rigid-hulled, inflatable boats (RHIBs) with crew and a Marine Special Operations Teams (MSOTs) 42 men platoon. The C2 functions will use existing installed C4ISR systems along with specialize Special Operations Force dedicated communications gear (delivered in module ISO container).

Special Operation Capabilities:

- a. Conduct covert beach survey in preparation for STOM
- b. C4I modular suite space to provide Task Unit commander (TUC) with communications and intelligence to direct SOF operations
- c. 11m NSW RHIB operations, day and night, to sea state 3
- d. Navy Special Warfare (NSW) Swimmer Delivery Vehicle (SDV)<sup>111</sup> day and night operations
- e. Refueling and logistic support as mother ship for Mk V Special Operations craft<sup>112</sup> and maintenance support team
- f. UAV video surveillance and over-watch of SOF operations by SOF Task Unit Commander
- g. Fully Networked Operations via TADIL with other assets and ISR
- h. Helicopter day and night flight operations, including insertion/extraction by two MH-60H or one CH-46/47 or one CH-53E. If only operating one MH-60H, SO teams can have up to three Sea Scout UAVs for fire support (see SUW modifications) or EO/ISR. The LCS would be capable of operating the new SOF Hummingbird<sup>113</sup> UAV (Up to 3 with one MH-60H).
- i. CSAR support
- j. MARSOC to recapture hijacked vessel from pirates

<u>Recommended SOF Module mission package</u>	<u>QTY</u>
1) SUW mission package	1
a. MH-60R helicopter	2
2) 11 m SOF RHIB or SDV	2
3) <u>Scan Eagle UAS</u> <sup>114</sup> launch/recovery system	1
4) 12-personnel berthing module	3
5) Armory / gear module	1
6) RHIB support module	1
7) C2 support ½ module	1

Note: module dimension is typical shipping container 20 ft L x 8 ft W x 7 ft H.

Joint Littoral Mobility for Logistics / Sea Basing Support. LCS in conjunction with Joint High Speed Vessels (JHSVs), shown in appendix M on page 63, have the capability to embark large payloads, transit at speeds 35 knots, and deliver to austere, shallow water ports or at sea. The

logistic support includes:

- a. The LCS has the potential to transport up to 145 combat Marines or 108 litters using a LCAC type personnel transport module (L-PTM). The module is delivered in a 20 ft x 8 ft x 8 ft shipping container (see figure (21) on page 64 for illustration).
- b. The JHSV has a 1200 nm range at 35 knots, payload of 635MT, with embarked troop berthing for 150 troops and airline style seating for 312 Troops. The JHSV flight deck can support up to a CH-53E. The roll-on and roll-off loading ramp can support austere loading of up to a M1A2 Abrams tanks (see figure (20) page 63). The mission deck has usable cargo area of 1800 square meters.
- c. A rapid on load / off load design means a very quick turnaround time increasing tempo and reducing vulnerability. Dependency on movements which traditionally have taken two to three weeks using airlift, spread out over several lifts with shifting priorities, on often unreliable schedules at high cost would no longer be necessary.

The LCS can serve as a flexible logistics support platform to provide sustainment for forces ashore from a sea base, to include modularized liquid transfer to multi-configurable bulk/solid container storage, cargo transfer to/from a combat logistics force ship, and helicopter refueling (in lily-pad mission).

Joint Littoral Mobility for Humanitarian Assistance, Disaster Relief, Medical support and Non-combatant Evacuation Operations. The LCS with its high speed and flexible internal volume configurations is ideal to support USMC response to crises requiring medical support, Non-Combatant Evacuation Operations (NEO), and Humanitarian Assistance. Prepared support modules airlifted to a port and loaded on the LCS, for subsequent delivery to disaster area. For medical support, the LCS can deliver and support a Forward Surgical Team of 20 personnel with equipment and supplies loaded in six HMMWVs with trailers or establish an offshore medical evacuation station at the deployment area. A squadron of one LCS (force protection with SUW package), one LCS (with two MH-60R), and one JHSV with roll-on-roll-off capability (see figure (20) on page 62) could quickly embark and deliver an 84-bed Combat Surgical hospital to support MAGTF ground operations or disaster relief. For NEO, a squadron of one LCS (force protection with SUW package), one LCS with MH-60R and one JHSV each with LCAC-type

personnel transport module (see Figure (21) on page 64).

Anti-piracy/drug patrols, Security Cooperation, Combat Search and Rescue (CSAR), Special Operations Forces support, Maritime Interdiction Operations and Homeland Defense/Anti-Terrorism/Force Protection. LCS is easily configured for the above key missions by embarking USMC detachments with their RHIBs, weapons and support equipment. Inherent LCS capabilities that can support the missions are:

- a. C4ISR networked for surveillance, identification, tracking, and interrogation of Contact-of-Interest (COI) vessels through use of on-board radar, UAV and helicopter
- b. High-speed for intercept of suspect vessels
- c. Heliborne or multiple RHIB insertion of VBSS team on target vessel
- d. LCS deck guns, UAV and armed helicopter over-watch and fire-support for protection of VBSS team
- e. LCS deck guns or armed helicopter for stop order compliance
- f. Combat Search and rescue of downed pilots

<u>Recommended MIO Module mission package</u>	<u>QTY</u>
1) SUW standard mission package	1
2) 12-personnel berthing module	2
3) 11 m RHIB	2
4) Armory / gear module	1
5) RHIB support module	1

Note: module dimension is typical shipping container 20 ft L x 8 ft W x 7 ft H.

LCS, deployed under the above missions, would conduct surveillance in designated operational area using shipboard, UAV, and helicopter EO/IR sensors to track COI vessels along shipping lanes. Using UAVs to conduct surveillance allows for an expanded surveillance area and 24/7 persistent MIO than the typical DDG or FFG. Once interrogation or intelligence deems a boarding necessary, the LCS can use high-speed to intercept suspect vessel and deploys VBSS team via RHIB or helicopter, while UAV and helicopter provides top-cover and over-watch. If target vessel refuses a stop order, the armed helicopter, UAV (if armed, see SUW modifications on page 43), or LCS 57 or 30 mm guns enforces compliance. After boarding, the vessel is detained or released based on results of VBSS analysis.

Scouting, ISR, IO and Deception Operations. LCS with ISR Scouting mission package would provide Marine Commander with sensor platform to provide targeting, battle damage assessment, sensor node in GCCS-M network, intelligence collection, and deception-decoy operations. The LCS high speed, sensors and unmanned vehicles is the perfect reconnaissance platform to patrol large operational areas.

<u>Recommended Scouting module mission package</u>	<u>QTY</u>
1) ASW mission package with	1
a. MH-60R	1
b. <u>RQ-8B Fire Scout helicopter (VTUAV)</u>	3
c. Spartan Unmanned Surface Vehicle	2
2) 12-personnel berthing module	2
3) C2 support module	1
Note: module dimension is typical shipping container 20 ft L x 8 ft W x 7 ft H.	

Linking the LCS Scouting and ISR mission package through FORCEnet to Cooperative Engagement Capability<sup>115</sup> (CEC) would improve warfighting capability in amphibious operations by enabling cooperating units to allocate radar energy to different areas of the battlefield, enlarging the area of radar coverage. Naval operations conducted in the littoral environment require that attacking enemy ship, aircraft, and missiles be detected and engaged over land or over water in the face of heavy land clutter. Search sector cooperation between the defending units using the LCS unmanned vehicles and sensors in CEC can significantly increase their detection and track ranges and consequently increase battle space. Additionally, the unmanned vehicles could provide an Engage-On-Remote (EOR) and Over-The-Horizon (OTH) defense capability that expands the battle space to the maximum kinematic range of the ESG weapons. Linking the LCS to the new Navy MQ-4 C Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System<sup>116</sup> (UAS) would improve the information dissemination to the fleet.

Naval Surface Fires Support (NSFS) Operations. With the cancellation of the Non-Line-of-Sight Launch System (NLOS-LS) missile system (NETFIRES<sup>117</sup>), the LCS has no NSFS capability in support of the MAGTF. LCS organic 57 mm gun is an inadequate NSFS weapon. Without extensive modifications to the hull via a new flight design, the LCS cannot provide a NSFS role using existing naval 5 inch 62mm gun or 155mm Advanced Gun System technology. The following options could provide future NSFS capability for the LCS:

- a. From the 55 planned LCS hulls, build a few GD, LM multi-mission variants of the LCS and configure with the Navy's future supersonic Advanced Land-Attack Missile. The two leading candidates are a naval version of the Lockheed Martin Vought Systems Army Tactical Missile System (ATACMS), which would have a range of 165 nautical miles, and a variant of the SM-2 Standard Block 3 air-defense missile, which could reach about 150 nautical miles. Both missiles could fit in the existing GD and LM launcher cells. The LM version with full-length strike cells could support the Tactical Tomahawk cruise missile with 1000+ nautical mile range.
- b. For a NSFS module, field a naval version of the high-mobility artillery rocket system (HIMARS)<sup>118</sup>. The HIMARS retains the same self-loading and autonomous features installed on the multiple-launch rocket system (MLRS) but is a wheeled variant that weighs half as much at 12 tons. The preferred HIMARS rocket for the NSFS mission would be the new Lockheed Martin extended range-guided rocket GMLRS with a range of more than 70 km. The HIMARS launcher carries a single six-pack of rockets. The naval version would reload rockets from a module magazine but rocket exhaust blow-back protection of the ship would have to be a design consideration. The LCS with this naval HIMARS module would provide as a firing platform for

what former Commandant General James Conway called a “box of rockets” to support NSFS for the Marines.<sup>119</sup>



## APPENDIX L – Tables

Table 2 shows the Navy's proposed five-year (FY2011-FY2015) shipbuilding plan.

**Table Navy Five-Year (FY2011-FY2015) Shipbuilding Plan**  
(Battle force ships—i.e., ships that count against 313-ship goal)

Ship type	FY11	FY12	FY13	FY14	FY15	Total
Ford (CVN-7B) class aircraft carrier			1			1
Virginia (SSN-774) class attack submarine	2	2	2	2	2	10
Arleigh Burke (DDG-51) class destroyer	2	1	2	1	2	8
Littoral Combat Ship (LCS)	2	3	4	4	4	17
San Antonio (LPD-17) class amphibious ship		1				1
Large-deck amphibious assault ship (LHA(R))	1					1
Fleet tug (TATF)					1	1
Mobile Landing Platform (MLP) ship	1		1		1	3
Joint High Speed Vessel (JHSV)	1	1	2	2	2	8
<b>TOTAL</b>	<b>9</b>	<b>8</b>	<b>12</b>	<b>9</b>	<b>12</b>	<b>50</b>

Source: FY2011 Navy budget submission.

### Table 1 – 5 Year Shipbuilding Plan

Source: CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans, Background and Issues for Congress*, 4, accessed 23 February 2011, <http://www.fas.org/sgp/crs/weapons/RL32665.pdf>.

### 30-Year (FY2011-FY2040) Shipbuilding Plan

Table shows the Navy's FY2011 30-year (FY2011-FY2040) shipbuilding plan. The plan includes a total of 276 ships.

**Table Navy 30-Year (FY2011-FY2040) Shipbuilding Plan**

FY	CVN	LSC	SSC	SSN	SSBN	AWFS	CLF	Supp	Total
11		2	2	2		1		2	9
12		1	3	2		1		1	8
13	1	2	4	2				3	12
14		1	4	2				2	9
15		2	4	2		4		4	12
16		1	3	2		1		2	9
17		2	3	2		1	1	3	12
18	1	1	3	1				3	9
19		2	3	2	1	1	1	3	13
20		1	2	2				4	9
21		2	2	2		2	1	2	11
22		1	2	2	1		1	3	10
23	1	2	2	1		1	1	3	11
24		1	2	1	1		1	2	8
25		1	1	1	1	2	1	1	8
26		2	2	1	1		1		7
27		2	1	1	1	1	1		7
28	1	1	2	1	1		1	1	8
29		2	1	1	1	2	1		8
30		1	2	1	1		1	2	8
31		2	1	1	1	1	1	1	8
32		2	2	1	1		1	1	8
33	1	2	1	1	1	2	1	2	11
34		2	2	1			1	2	8
35		2	2	2		1	1	2	10
36		2	2	1				2	7
37		2	2	2		1	1	2	10
38	1	2	2	1		1		2	9
39		2	2	2		1	1	2	10
40		2	2	1				2	7

Source: Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2009.

Key: FY = Fiscal Year; CVN = aircraft carriers; LSC = surface combatants (i.e., cruisers and destroyers); SSC = small surface combatants (i.e., Littoral Combat Ships [LCSs]); SSN = attack submarines; SSBN = cruise missile submarines; SSBN = ballistic missile submarines; AWS = amphibious warfare ships; CLF = combat logistics force (i.e., resupply) ships; MPP(F) = Maritime Prepositioning force (future) ships; Supp = support ships.

### Table 2 – 30 Year Shipbuilding Plan

Source: CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans, Background and Issues for Congress*, 4, accessed 23 February 2011, <http://www.fas.org/sgp/crs/weapons/RL32665.pdf>.

**Table 3 – Examples of Littoral Combat Ship Missions**

<b>Focused missions</b>	<b>Examples of tasks</b>
Littoral mine warfare	<ul style="list-style-type: none"> <li>• Detect, avoid, and/or neutralize mines</li> <li>• Clear transit lanes</li> <li>• Establish and maintain mine cleared areas</li> </ul>
Littoral antisubmarine warfare	<ul style="list-style-type: none"> <li>• Detect all threat submarines in a given littoral area</li> <li>• Protect forces in transit</li> <li>• Establish antisubmarine barriers</li> </ul>
Littoral surface warfare	<ul style="list-style-type: none"> <li>• Detect, track, and engage small boat threats in a given littoral area</li> <li>• Escort ships through choke points</li> <li>• Protect joint operating areas</li> </ul>
<b>Inherent Missions</b>	
Battle space awareness	<ul style="list-style-type: none"> <li>• Intelligence, surveillance, and reconnaissance</li> </ul>
Joint littoral mobility	<ul style="list-style-type: none"> <li>• Provide transport for personnel, supplies and equipment within the littoral operating area</li> </ul>
Special operations forces support	<ul style="list-style-type: none"> <li>• Provide rapid movement of small groups of special operations forces personnel</li> <li>• Support hostage rescue operations</li> <li>• Support noncombatant evacuation operations</li> <li>• Support and conduct combat search and rescue</li> </ul>
Maritime interdiction/interception	<ul style="list-style-type: none"> <li>• Provide staging area for boarding teams</li> <li>• Employ and support MH-60 helicopters for maritime interdiction operations</li> <li>• Conduct maritime law enforcement operations, including counternarcotic operations, with law enforcement detachment</li> </ul>
Homeland defense	<ul style="list-style-type: none"> <li>• Perform maritime interdiction/interception operations in support of homeland defense</li> <li>• Provide emergency, humanitarian and disaster assistance</li> <li>• Conduct marine environmental protection</li> <li>• Perform naval diplomatic presence</li> </ul>
Antiterrorism/force protection	<ul style="list-style-type: none"> <li>• Perform maritime interdiction/interception operations in support of force protection operations</li> <li>• Provide port protection for U.S. and friendly forces and protection against attack in areas of restricted maneuverability</li> </ul>

Source: GAO from U.S. Navy sources.

Source: GAO report 05-255, March 2005, 6, accessed 21 February 2011, <http://www.gao.gov/new.items/d05255.pdf>

**Table 4 – Examples of Mission Warfare Tasks and Related Capability Gaps in the Littorals**

<b>Mission task</b>	<b>Criteria to measure success</b>	<b>Capability gaps identified with current and programmed force structure</b>
Mine Warfare: Establish and maintain mine-cleared areas	Clearing transit lanes within 7 days	Inadequate number of mine countermeasures assets in the force to clear transit lanes within seven days.
Antisubmarine warfare: Protect joint operating areas	Detecting submarines at 90 percent success rate	Inadequate number of assets and technology to detect submarines in shallow water at 90 percent success rate.
Surface warfare: Escort through choke points	Neutralizing large sets of small boats in a single raid	Gaps exist in coverage areas in defeating 50 or more small boats, due to shortfall in the numbers of assets. Surface combatant ships and helicopters only provide self defense protection.
Protect port	Neutralizing small sets of small boats in a single raid	Inadequate number of surface combatant assets and technology exists for defeating small boat raid in port operating area. Helicopters provide self defense capability only in port operating area.

Source: GAO from Navy sources.

Source: GAO report 05-255, March 2005, 15, accessed 21 February 2011, <http://www.gao.gov/new.items/d05255.pdf>

NUMBER	DESCRIPTION	DEFINITION	WINDS (KTS)	AVG WAVE HEIGHT (FT)	SEA STATE EQUIVALENT (NOTE 1)
1	LIGHT AIRS	RIPPLES W/APPEARANCE OF SCALES.	1-3	0.05	0
2	LIGHT BREEZE	SMALL WAVELETS, GLASSY APPEARANCE.	4-6	0.18	0-1
3	GENTLE BREEZE	LARGE WAVELETS, CRESTS BEGIN TO BREAK.	7-10	0.6-0.88	1-2
4	MODERATE BREEZE	SMALL WAVES BECOMING LARGE WAVES, WHITE CAPS APPEAR.	11-16	1.40-2.90	2-3
5	FRESH BREEZE	MANY WHITE CAPS, CHANCE OF SEA SPRAY.	17-21	3.80-5.00	3-4
6	STRONG BREEZE	LARGE WAVES BEGIN TO FORM FOAM CRESTS EXTENSIVE PROBABLY SPRAY.	22-27	6.40-9.60	4-5
7	MODERATE GALE	SEA HEAPS UP, WHITE FOAM BLOWS IN STEAKS SPINDRIFT IS SEEN.	28-33	11-16	5-6
8	FRESH GALE	MODERATELY HIGH WAVES OF GREATER LENGTH. FOAM IS BLOWN SPARY AFFECTS VISIBILITY.	34-40	19-28	6-7
9	STRONG GALE	HIGH WAVES, DENSE FOAM STREAKS, SEA BEGINS TO ROLL.	41-47	31-40	7-8

**Table 5 - Beaufort Scale for Sea States**

**Source:** <http://www.sbsa.info/archives/beau.htm>, accessed 21 February 2011.

**Table 6 – The Navy’s Evolving Force-Structure Requirements**

	Requirements for a 313-Ship Fleet in the Navy’s 2009 Plan	Requirements Implied in the Navy’s 2011 Plan
Aircraft Carriers	11	10-11
Submarines		
Attack	48	48
Guided missile	4	0
Ballistic missile	14	12
Large Surface Combatants		
Cruisers	10	0
Destroyers	69	88 <sup>a</sup>
Littoral Combat Ships	55	55
Amphibious Ships	31	33
MPF(F) Ships	12	0
Combat Logistics Ships	30	30
Support Ships		
Joint high-speed vessels	3	23
Other <sup>b</sup>	17	23 <sup>c</sup>
<b>Total</b>	<b>313</b>	<b>322-323 <sup>a</sup></b>

Source: Congressional Budget Office.

Note: MPF(F) = Maritime Prepositioning Force (Future).

- a. The minimum implied requirement. If the requirement for destroyers ended up being higher than 88, the total requirement for the fleet could exceed 322 to 323 ships.
- b. Includes command ships, logistics ships, salvage ships, ocean tugs, surveillance ships, and tenders.
- c. Includes three logistics ships and three scaled-down versions of the multiple landing platform ship to augment existing maritime prepositioning squadrons.

**Source:** Congressional Budget Office (CBO), *An Analysis of the Navy’s Fiscal Year 2011 Shipbuilding Plan*, May 2010, 2, accessed 14 February 2011, <http://www.cbo.gov/ftpdocs/115xx/doc11527/05-25-NavyShipbuilding.pdf>

## APPENDIX M – Joint High Speed Vessel

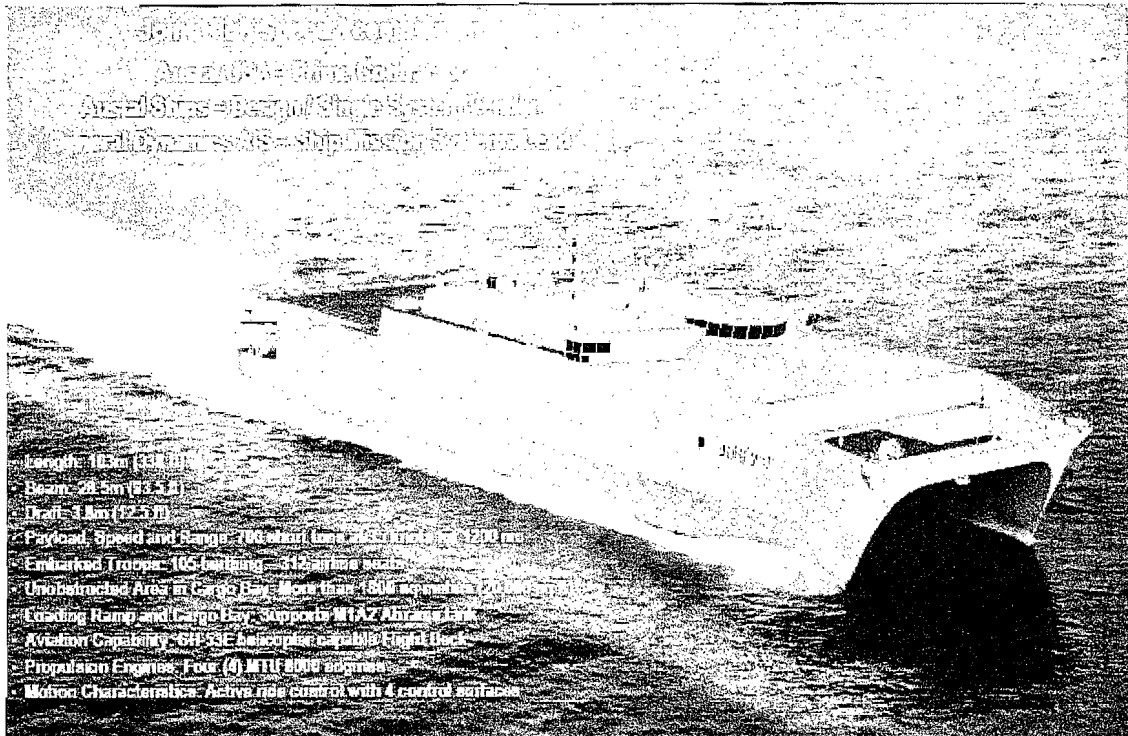


Figure 19 – Joint High-Speed Vessel (JHSV)

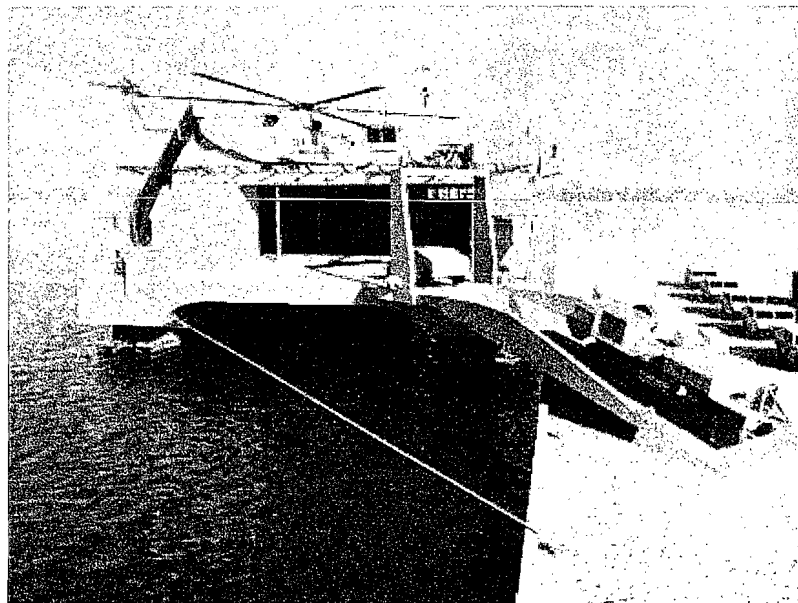


Figure 20 – JHSV roll-on roll-off capability

Source: <http://www.austal.com/index.cfm?objectID=6B42CC62-65BF-EBC1-2E3E308BACC92365>



## PERSONNEL TRANSPORT MODULE

### History

2 prototypes developed/delivered 1994-95

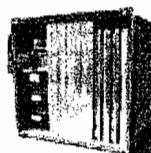
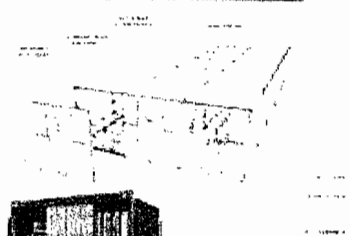
7 production units delivered 1997-98

### Key Features

Installs by manpower only w/o crane/forklift  
< 4 hrs

Lightweight panels can be carried/assembled  
by 2-4 people

Capacity: up to 180 seated passengers, 145  
combat-load Marines, up to 108 litters



Deployable  
pack-up kit,  
stows in one 8' x  
20' ISO container

**Figure 21 – LCAC Personnel Transport Module (PTM)**

**Source:** Amphibious Warfare Program (PMS377) Overview, accessed 24 February 2011, [www.asnetw.org/asne/events/RiedelTalk.ppt](http://www.asnetw.org/asne/events/RiedelTalk.ppt)

## APPENDIX N – Glossary

**C4ISR**—Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance.

**Cooperative Engagement Capability (CEC)**—CEC enables the networking of sensors among multiple ships equipped with multiple types of sensors throughout the operating area, thereby enhancing the ability of the CEC-equipped ship to track and destroy incoming Anti-Ship Missiles (ASMs). CEC also provides a capability, referred to as "engage on remote," whereby a ship that does not originate the tracking data can launch missiles at targets within the weapons range identified in the CEC composite track picture

**distributed Operations**—is a form of maneuver warfare where small, highly capable units spread across a large area of operations will create an advantage over an adversary through the deliberate use of separation and coordinated, independent tactical actions. DO units will use close combat or supporting arms to disrupt the enemy's access to key terrain and avenues of approach. This type of warfare will be dependent on well-trained and professional small unit leaders, focused and energetic training of small units and more robust communications and tactical mobility assets for those smaller units. A greater focus will also be placed on language and cultural training.

**Deployment, Management, Exploitation, Refueling, Repositioning, Recovering, Replacement, Redeployment (DMER5)**—sensor capabilities of Littoral combat ship while operating unmanned vehicles.

**Expanded Maritime Interdiction Operations (EMIO)** — EMIO refers to national and international partnerships of military and maritime law-enforcement entities, which detain, divert, disrupt, or destroy vessels used to conduct illegal or hostile activities.

**forward presence**—(NDP 1) Maintaining forward deployed or stationed forces overseas to demonstrate national resolve, strengthen alliances, dissuade potential adversaries, and enhance the ability to respond quickly to contingency operations.

**GCCS-M**—The Global Command and Control System -Maritime is the Navy's single command and control program-of-record that integrates and interfaces over 80 separate C4I systems providing naval commanders afloat and ashore a near-real-time Common Operating Picture (COP).

**Littoral Penetration Point**—a point in an LPS where the actual transition from waterborne to land borne movement occurs ("feet wet" to "feet dry" for flying elements).

**Littoral Penetration Site**—a continuous segment of coastline within an LPZ through which landing forces cross by surface or vertical means.

**Maritime security operations**—those operations conducted to protect sovereignty and resources, ensure free and open commerce, and to counter maritime-related terrorism, transnational crime, piracy, environmental destruction, and illegal seaborne immigration.

**maritime superiority**—(DOD). That degree of dominance of one force over another that permits the conduct of maritime operations by the former and its related land, maritime, and air forces at a given time and place without prohibitive interference by the opposing force.

**military engagement**—(DOD) Routine contact and interaction between individuals or elements of the Armed Forces of the United States and those of another nation's armed forces, or foreign and domestic civilian authorities or agencies to build trust and confidence, share information, coordinate mutual activities, and maintain influence.

**Mission Package**—is an interchangeable package that is used to configure LCS for its primary warfighting role. Mission Packages are developed for ASW, MIW and SUW missions. Each package may consist of manned and unmanned vehicles, deployable sensors, specially trained mission module personnel and several cargo containers housing the command and control elements. These cargo containers will integrate with the seaframe creating a cohesive surface combatant specializing in any one warfare area.

**Maritime Preposition Force (MPF)**—MSC prepositioning ships are especially configured to transport supplies for the U.S. Marine Corps.

**Mine Warfare Environmental Decision Aids Library (MEDAL)**—segment allowing extensive data sharing between mine warfare and amphibious warfare planners. The primary goal of Expeditionary Decision Support System (EDSS) is to provide the ability to execute true distributed and collaborative planning for amphibious operations, including ship-to-objective maneuver, selected intelligence and meteorological functions, and maneuver plan rehearsal in the littoral/expeditionary warfare area.

**Naval Logistics Integration**—A coordinated Navy-Marine Corps effort that establishes an integrated naval logistics capability that can operate seamlessly afloat or ashore.

**NMWS**—Naval Mine Warfare Simulation

**Non-combatant evacuation operations (NEO)**—(DOD) Operations directed by the Department of State or other appropriate authority, in conjunction with the Department of Defense, whereby noncombatants are evacuated from foreign countries when their lives are endangered by war, civil unrest, or natural disaster to safe havens or to the United States. Also called NEOs.

**Operational Maneuver from the Sea (OMTS)**—describes rapid maneuver by landing forces from their ships directly to objectives ashore, uninterrupted by topography or hydrography.

**power projection**—(DOD) The ability of a nation to apply all or some of its elements of national power—political, economic, informational, or military—to rapidly and effectively deploy and sustain forces in and from multiple dispersed locations to respond to crises, to contribute to deterrence, and to enhance regional stability.

**Q-routes**—a system of preplanned shipping lanes in mined or potentially mined waters used to minimize the area the mine countermeasures commander has to keep clear of mines in order to provide safe passage for friendly shipping.

**seabasing**—(DOD) The deployment, assembly, command, projection, reconstitution, and re-employment of joint power from the sea without reliance on land bases within the operational area.

**Seaframe**—is the ship platform and all of its inherent combat capabilities. Free standing with no mission module a seaframe will be able to perform all self-defense measures, navigation, C4I and air and small boat operations. LCS Seaframe is the core platform of the LCS and the naval equivalent of an airframe.



**sea control operations**—(DOD) The employment of naval forces, supported by land and air forces as appropriate, in order to achieve military objectives in vital sea areas. Such operations include destruction of enemy naval forces, suppression of enemy sea commerce, protection of vital sea lanes, and establishment of military superiority in areas of naval operations.

**security assistance**—(DOD) Group of programs authorized by the Foreign Assistance Act of 1961, as amended, and the Arms Export Control Act of 1976, as amended, or other related statutes by which the United States provides defense articles, military training, and other defense-related services by grant, loan, credit, or cash sales in furtherance of national policies and objectives. Also called SA.

**security cooperation**—(DOD) All Department of Defense interactions with foreign defense establishments to build defense relationships that promote specific U.S. security interests, develop allied and friendly military capabilities for self-defense and multinational operations, and provide U.S. forces with peacetime and contingency access to a host nation.

**Ship-to-Objective Maneuver (STOM)**—employs the concepts of maneuver warfare to project a combined arms force by air and surface means against inland objectives.

**SIPRNET**—The Secret Internet Protocol Router Network (SIPRNET) is the Department of Defense's largest network for the exchange of classified information and messages at the SECRET level. It supports the Global Command and Control System, the Defense Message System, and numerous other classified warfighting and planning applications.

**SLOC** – Sea Lanes of Communication

**Source:** Naval Operations Concept 2010 (NOC 10), ANNEX B, Glossary

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<sup>1</sup> U.S. Department of the Navy, "A Cooperative Strategy for 21st Century Seapower," (Washington, DC: US Department of the Navy, October 2007), accessed February 08, 2011, <http://www.navy.mil/maritime/MaritimeStrategy.pdf>.

<sup>2</sup> United States Marine Corps, "A Concept for Distributed Operations," (Washington, DC, Department of the Navy, Headquarters United States Marine Corps, 25 April 2005), I-III, accessed 07 February 2011, <https://www.mccdc.usmc.mil/FeatureTopics/DO/A%20Concept%20for%20Distributed%20Operations%20-%20Final%20CMC%20signed%20co.pdf>.

"Distributed Operations is a form of maneuver warfare where small, highly capable units spread across a large area of operations will create an advantage over an adversary through the deliberate use of separation and coordinated, independent tactical actions. DO units will use close combat or supporting arms to disrupt the enemy's access to key terrain and avenues of approach. This type of warfare will be dependent on well-trained and professional small unit leaders, focused and energetic training of small units and more robust communications and tactical mobility assets for those smaller units. A greater focus will also be placed on language and cultural training."

<sup>3</sup> Christopher P. Cavas, "Pentagon Starts Study of Post-Afghan Marine Corps," *Defense News*, August 10, 2010, accessed February 07, 2011, <http://www.defensenews.com/story.php?c=SEA&s=TOP&i=4733973>.

<sup>4</sup> United States Marine Corps, "Marine Corps Operating Concepts (MOC) Third Edition," (Washington, DC, Department of the Navy, Headquarters United States Marine Corps, June 2010), 29-30, accessed February 22, 2011, [http://www.quantico.usmc.mil/seabasing/docs/MOC%20July%2013%20update%202010\\_Final.pdf](http://www.quantico.usmc.mil/seabasing/docs/MOC%20July%2013%20update%202010_Final.pdf).

<sup>5</sup> Source: Navy Fleet size numbers initially presented to Congress in February 2006.

<sup>6</sup> Ronald O'Rourke, "Navy LPD-17 Amphibious Ship Procurement: Background, Issues, and Options for Congress," CRS Report RL34476, (Congressional Research Service (CRS), Washington DC, October 15, 2010), 1, accessed February 22, 2011, <http://www.fas.org/sgp/crs/weapons/RL34476.pdf>.

<sup>7</sup> Ronald O'Rourke, "Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress," CRS Report RL33745, (Congressional Research Service (CRS), Washington DC, June 10, 2010), 14, accessed February 21, 2011, <http://www.fas.org/sgp/crs/weapons/RL33745.pdf>.

<sup>8</sup> Ronald O'Rourke, "Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress," CRS Report RL32109, (Congressional Research Service (CRS),

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Washington DC, June 14, 2010), 7, accessed March 03, 2011, <http://www.fas.org/sgp/crs/weapons/RL32109.pdf>.

<sup>9</sup> “Joint High Speed Vessel,” Austal, last modified February 21, 2011, accessed February 22, 2011, <http://www.austal.com/index.cfm?objectID=6B42CC62-65BF-EBC1-2E3E308BACC92365>.

<sup>10</sup> Congressional Budget Office (CBO), “An Analysis of the Navy’s Fiscal Year 2011 Shipbuilding Plan, May 2010,” (Washington, DC, May 2010), 2, accessed 14 February 2011, <http://www.cbo.gov/ftpdocs/115xx/doc11527/05-25-NavyShipbuilding.pdf>.

“Navy shipbuilding plans no longer call for building a 12-ship squadron of next generation Maritime Prepositioning Force (Future), or MPF(F), ships; they now call for building six new maritime prepositioning ships—three Lewis and Clark (TAKE-1) class dry cargo ships (which have already been funded) and three Mobile Landing Platform (MLP) ships—that are to augment the three existing squadrons of maritime prepositioning ships.”

<sup>11</sup> “An Analysis of the Navy’s Fiscal Year 2011 Shipbuilding Plan,” vii, 2.

<sup>12</sup> Ronald O'Rourke, “Navy Force Structure and Shipbuilding Plans, Background and Issues for Congress,” CRS Report RL32665, (Congressional Research Service (CRS), Washington DC, August 17, 2010), 5, accessed 23 February 2011, <http://www.fas.org/sgp/crs/weapons/RL32665.pdf>.

<sup>13</sup> U.S. Department of the Navy, “Naval Operations Concept 2010 (NOC 10),” (Department of the Navy, Washington, DC, June 2010), 99, accessed 23 February 2011, <http://www.navy.mil/maritime/noc/NOC2010.pdf>.

“Security Cooperation is all Department of Defense interactions with foreign defense establishments to build defense relationships that promote specific U.S. security interests, develop allied and friendly military capabilities for self-defense and multinational operations, and provide U.S. forces with peacetime and contingency access to a host nation.”

<sup>14</sup> USMC, MOC, 65-66.

“A SC MAGTF will be able to conduct sequential, simultaneous, or overlapping missions of varying duration and location by task-organizing and deploying:

- *Training, Advisor, and Assessment Teams* of 5-15 Marines and Sailors who will episodically deploy for short-duration missions of approximately 15 days.
- *Detachments* of 15-200 Marines and Sailors who will episodically deploy for medium-duration missions of 30-90 days.
- *Special purpose MAGTFs for Security Cooperation (SCMAGTF)* of 200-500 Marines and Sailors who will episodically deploy for longer-duration missions of 90-150 days.

SC MAGTFs are not envisioned to have significant crisis response capabilities. However, like all MAGTFs, Marines will possess the basic skills to conduct limited reinforcement as required.

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These SC MAGTFs will operate with a diverse set of partners. In many locales, Marines and Special Operations Forces (SOF) will be conducting parallel operations—simultaneously. Efforts must be made to integrate activities or ensure they complement one another. Marine units can both leverage SOF (e.g. established relationships with local military/civilian leaders, intelligence sources) and support SOF (e.g. mobility, logistics). Establishing relationships and sharing information early in predeployment training will increase synergy once deployed.”

<sup>15</sup> U.S. Department of the Navy, “...From the Sea: Preparing the Naval Service for the 21st Century,” (Washington, DC: U.S. Government Printing Office, September 1992).

<sup>16</sup> U.S. Department of the Navy, “Forward...From the Sea,” (Washington, DC: U.S. Government Printing Office, September 1994).

<sup>17</sup> Vern Clark, Admiral, USN, Chief of Naval Operations, “Sea Power 21, Projecting Decisive Joint Capabilities,” *Proceedings*, October 2002, 33-34.

“*Sea Power 21* establishes the guiding principles for the Navy’s future: To realize the opportunities and navigate the challenges ahead, we must have a clear vision of how our Navy will organize, integrate, and transform. “*Sea Power 21*” is that vision. It will align our efforts, accelerate our progress, and realize the potential of our people. “*Sea Power 21*” will guide our Navy as we defend our nation and defeat our enemies in the uncertain century before us. *Sea Power 21* is a change from the US Navy’s blue-water doctrine, which focused on the deep-water battle, to an increased focus on the littoral environment. The LCS is designed to support all three of the *Sea Power 21* pillars: Sea Strike, Sea Shield, and Sea Basing.”

<sup>18</sup> U.S. Joint Forces Command, “Joint Doctrine Encyclopedia,” 16 July 1997, 464.

<sup>19</sup> Royal Institution of Naval Architects 2004, “Warship 2004: Littoral warfare & the expeditionary force,” (paper presented at 2004 International conference in London for Royal Institution of Naval Architects).

<sup>20</sup> Raphael Perl and Ronald O’Rourke, “Terrorist Attack on USS Cole: Background and Issues for Congress,” CRS Report RS20721, (Congressional Research Service (CRS), Washington DC, updated January 30, 2001), accessed March 03, 2011, <http://fll.findlaw.com/news.findlaw.com/cnn/docs/crs/coleterrattck13001.pdf>.

“On October 12, 2000, the U.S. Navy destroyer Cole was attacked by a small boat laden with explosives during a brief refueling stop in the harbor of Aden, Yemen. The suicide terrorist attack killed 17 members of the ship’s crew, wounded 39 others, and seriously damaged the ship. Evidence developed to date suggests that it may have been carried out by Islamic militants with possible connections to the terrorist network led by Osama bin Laden.”

<sup>21</sup> “*Eilat* Class Sa’ar 5 Multi-mission Corvettes, Israel,” Navy Technology.com, accessed March 03, 2011, <http://www.naval-technology.com/projects/saar5/>.

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“While taking part in the Israeli Navy blockade of Lebanese ports in July 2006, INS *Hanit* was struck by an anti-ship missile fired by Hezbollah. Four crewmembers were killed. A fire resulted from the attack and the ship was able to return to Ashdod port under its own power. Following repairs, the vessel was reported to have resumed its combat role in August 2006.”

<sup>22</sup> Office of the Chairman, Joint Chiefs of Staff, “Fourth Endorsement on Formal Investigation into the Circumstances Surrounding the Attack on the USS Stark FFG-31 on 17 May 1987,” (Joint Chiefs of Staff, Washington, DC, September 03, 1987), accessed March 07, 2011, <http://www.jag.navy.mil/library/investigations/USS%20STARK%20BASIC.pdf>.

The USS Stark FFG-31 was operating off the coast of Bahrain in international waters when two Exocet missiles launched from an Iraqi F-1 Mirage fighter struck without warning. Even though the fighter was detected and queried as part of standard procedure, there was no detection of the missile launch.

<sup>23</sup> “Thunder And Lightning”- The War with Iraq,” Naval Historical Center Website, accessed March 03, 2011, <http://www.history.navy.mil/wars/dstorm/ds5.htm>.

“During Desert Storm, while sweeping toward the Shore of Faylaka Island on 17 February 1991, Iraqi Silkworm anti-ship missile fire control radars in Kuwait targeted the MCM force. The ships moved out of the missile's range while Coalition forces located and attacked the radar site. With the Silkworm missile threat diminished, the MCM forces began to move back to the previous minesweeping areas at 0240 on 18 February. At 0435, after operating for 11 hours in an undetected Iraqi minefield, USS *Tripoli* hit a moored contact mine in 30 meters of water. The explosion ripped a 16-foot by 20-foot hole below the water line. As USS *Avenger* and USS *Leader* attempted to assist the *Tripoli*, the USS *Princeton* (CG 59), continued to provide air defense for the MCM Group. At 0715, USS *Princeton* actuated a Manta mine in 16 meters of water. A sympathetic actuation of another mine about 350 yards from USS *Princeton* occurred about three seconds later. These mine blasts caused substantial damage to USS *Princeton*, including a cracked superstructure, severe deck buckling, and a damaged propeller shaft and rudder.”

<sup>24</sup> Robert O. Work, “Naval Transformation and the Littoral Combat Ship,” (Center for Strategic and Budgetary Assessments, Washington, DC, 2004), 45–46, accessed March 03, 2011, <http://www.csbaonline.org/4Publications/PubLibrary/R.20040218.LCS/R.20040218.LCS.pdf>.

<sup>25</sup> Arthur K. Cebrowski, Vice Admiral, USN and Wayne P. Hughes, Jr., Captain, USN, “Rebalancing the Fleet,” *Proceedings*, November 1999.

<sup>26</sup> Andrew Krepinevich, Barry Watts and Robert Work, “Meeting the Anti-Access and Area-Denial Challenge,” (Center for Strategic and Budgetary Assessments, Washington, DC, 2003), ii, accessed March 04, 2011, [http://www.csbaonline.org/4Publications/PubLibrary/R.20030520.Meeting\\_the\\_Anti-A/R.20030520.Meeting\\_the\\_Anti-A.pdf](http://www.csbaonline.org/4Publications/PubLibrary/R.20030520.Meeting_the_Anti-A/R.20030520.Meeting_the_Anti-A.pdf).

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“Anti-access (A2) strategies aim to prevent U.S. forcible entry into a theater of operations; area-denial (AD) operations aim to prevent the U.S. freedom of action in the more narrow confines under an enemy’s direct control.”

<sup>27</sup> U.S. Department of the Navy, “FORCENet: A Functional Concept for the 21<sup>st</sup> Century,” (Department of the Navy, Washington, DC, 2005), 1, accessed February 09, 2011, <http://www.navy.mil/navydata/policy/forcenet/forcenet21.pdf>.

FORCENet is a broad DoN initiative to implement network centric warfare through the Naval force by enabling robust information sharing and collaboration between warriors, weapons, sensors, command and control systems, support systems and platforms from seabed to space and sea to land.

<sup>28</sup> Clark, “Sea Power 21,” 34.

The three *Sea Power 21* pillars: Sea Strike, Sea Shield, and Sea Basing will be molded together by what the Navy calls ForceNet that will integrate warriors, sensors, command and control, platforms, and weapons into a networked, distributed combat force.

<sup>29</sup> DON, “NOC10,” 99.

“Sea Control operations is the employment of naval forces, supported by land and air forces as appropriate, in order to achieve military objectives in vital sea areas. Such operations include destruction of enemy naval forces, suppression of enemy sea commerce, protection of vital sea-lanes, and establishment of military superiority in areas of naval operations.”

<sup>30</sup> DON, “NOC10,” 3.

<sup>31</sup> DON, “NOC10,” 88.

<sup>32</sup> Ronald O’Rourke, “Navy ship acquisition: Options for lower-cost ship designs – issues for congress,” CRS Report RL32914, (Congressional Research Service (CRS), Washington DC, 2005, updated June 23, 2005), 15-16, accessed March 04, 2011, <http://www.fas.org/sgp/crs/weapons/RL32914.pdf>.

<sup>33</sup> “Littoral Combat Ship Platform Wholeness Concept of Operations (Revision C),” U.S. Fleet Forces Command, Sept. 24, 2009, Global Security, accessed March 01, 2011, <http://www.globalsecurity.org/military/library/report/2003/LCSCONOPS.htm>.

<sup>34</sup> “Littoral Combat Ship Flight 0 Preliminary Design Interim Requirements document (PD-IRD),” February 10, 2003, Global Security, accessed March 01, 2011, <http://www.globalsecurity.org/military/library/report/2003/03r2309-attach-j-4.pdf>.

<sup>35</sup> DON, Navy, Navy Warfare Development Command (NWDC), “Littoral Combat Ship Concept of Operations,” December 2004, v.

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<sup>36</sup> DON, NWDC, "Littoral Combat Ship Concept of Operations," ii.

<sup>37</sup> "MH-60R Seahawk," Global Security, accessed March 04, 2011, <http://www.globalsecurity.org/military/systems/aircraft/sh-60r.htm>.

<sup>38</sup> "CH-53E Super Stallion," Global Security, accessed March 04, 2011, <http://www.globalsecurity.org/military/systems/aircraft/ch-53e.htm>

<sup>39</sup> "CH-46 Sea Knight," Global Security, accessed March 04, 2011, <http://www.globalsecurity.org/military/systems/aircraft/ch-46.htm>

<sup>40</sup> "The Fire Scout VTUAV Program: By Land and By Sea," Olive-drab.com, accessed February 09, 2011, [http://www.olive-drab.com/idphoto/id\\_photos\\_uav\\_mq8.php](http://www.olive-drab.com/idphoto/id_photos_uav_mq8.php).

Northrop Grumman, RQ-8B Fire Scout helicopter Vertical Takeoff Unmanned Aerial Vehicle (VTUAV) will employ the Tactical Control System (TCS) and the Tactical Common Data Link (TCDL) as the primary means for UAS command and control and Sea Power for a New Era Sea Shield sensor payload dissemination. Fire Scout is a critical component of off-board sensors.

Design specifications:

Payload & armament EO/IR sensor package; Hellfire missiles; Viper Strike glide weapons

Engine: Rolls Royce 250-C20W heavy fuel turbo shaft engine

Speed: 115 knots Range 110 nm, 6 hours flight time Ceiling 20,000 ft

Span: 27.5 ft. (rotor diameter) Length 31.7 ft. Height 9.8 ft. Weight 2,073 lbs. (empty); 3,150 lbs. (max. takeoff weight).

<sup>41</sup> "Independence Class LCS," General Dynamics, accessed February 09, 2011, <http://www.gdlcs.com/independence-class-lcs> and "Freedom Class LCS," Lockheed Martin, accessed February 09, 2011, <http://www.lockheedmartin.com/products/LittoralCombatShip/>.

<sup>42</sup> "V-22 Osprey," Global Security, accessed March 04, 2011, <http://www.globalsecurity.org/military/systems/aircraft/v-22-specs.htm>.

<sup>43</sup> "BAE Systems 57-mm Mk 110 Mod 0 Naval Gun System," Defense Industry Daily, last modified April 10, 2007, accessed February 09, 2011, <http://www.defenseindustrydaily.com/bae-receives-3rd-lcs-contract-for-mk110-gun-03199/>.

<sup>44</sup> "RIM-116 Rolling Airframe Missile System," Navysite.de, accessed February 09, 2011, <http://www.navysite.de/launcher/ram.htm>.

Primary Function: Surface-to-Air-Missile

Contractor: Hughes Missile Systems Company and RAM Systems Germany

Diameter of Missile: 5 inch (12.7 cm)

Length of Missile: 9.18 feet (2.8 meters)

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Speed of Missile: 2+ Mach  
Range: approx. 11 miles  
Cost: Unit cost Block 0: \$273,000  
Unit cost Block 1: \$444,000  
Launcher: MK-43 (Standard) or modified MK-29

<sup>45</sup> "Raytheon Missile Systems Rolling Airframe Missile (RAM) Guided Missile Weapon System," Raytheon, accessed February 09, 2011, <http://www.raytheon.com/capabilities/products/ram/>.

<sup>46</sup> "Northrop Grumman Offers Proven Open-Architecture Solutions to Meet the Navy's Cost and Performance Goals, Integrated Combat Management System (ICMS)," Northrop Grumman, accessed February 09, 2011, <http://www.northropgrumman.com/news/es/2009/12/179542.html>.

<sup>47</sup> "Tactical Data Links - MIDS/JTIDS Link 16, and Variable Message Format – VMF," Lockheed Martin, accessed February 09, 2011, [http://www.lm-isgs.co.uk/defence/datalinks/link\\_16.htm](http://www.lm-isgs.co.uk/defence/datalinks/link_16.htm).

<sup>48</sup> "Tactical Data Links - Link 11 and 11B," Lockheed Martin, accessed February 09, 2011, [http://www.lm-isgs.co.uk/defence/datalinks/link\\_11.htm](http://www.lm-isgs.co.uk/defence/datalinks/link_11.htm).

<sup>49</sup> "Military Analysis Network FAS, Cooperative Engagement Capability (CEC) AN/USG-2(V) Cooperative Engagement Transmission Processing Set," Military Analysis Network (FAS), last modified February 16, 2000, accessed 09 February 2011, <http://www.fas.org/man/dod-101/sys/ship/weaps/cec.htm>.

"Raytheon's Cooperative Engagement Capability (CEC) brings revolutionary new capability to naval air and missile defense, not by adding new radars or weapon systems, but by distributing sensor and weapons data from existing systems in a new and significantly different manner. CEC fuses high quality tracking data from participating sensors and distributes it to all other participants in a filtered and combined state, using identical algorithms to create a single, common air defense tactical display ("air picture"). The result is a superior air picture based on all sensor data available that permits significantly earlier detection and more consistent tracking of air contacts. CEC was designed against the air threat (e.g., from cruise missiles), especially in littoral waters. Undergirding CEC is a robust communications system with several orders of magnitude in improvement to bandwidth and electronic countermeasures, as well as the systemic advantages offered by the global positioning system (GPS).

CEC improves warfighting capability in amphibious operations by enabling cooperating units to allocate radar energy to different areas of the battlefield, enlarging the area of radar coverage. Naval operations conducted in the littoral environment require that attacking aircraft and missiles be detected and engaged over land or over water in the face of heavy land clutter. Search sector cooperation between the defending ships using CEC can significantly increase their detection and track ranges and consequently increase battle space.



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Operating independently, without CEC, each of the ships must spread its radar energy over the entire volume, limiting the time and energy available to search in the difficult land clutter region. Operating together, with CEC, a single ship can search the entire volume while the other ships concentrate on the land clutter region. Data from each ship are distributed to all the ships and combined into an identical composite track picture on each ship. This picture, superior to that available from any single sensor, allows significantly earlier detection and more consistent track on attackers in the clutter.”

<sup>50</sup> “Sea Giraffe Amb – 3D Naval Surveillance Radar,” SAAB, accessed February 09, 2011, [http://www.saabgroup.com/Naval/Situational-Awareness/Multi-role-Surveillance-Radar/Sea\\_Giraffe\\_AMB/](http://www.saabgroup.com/Naval/Situational-Awareness/Multi-role-Surveillance-Radar/Sea_Giraffe_AMB/).

<sup>51</sup> “MK 36 Super Rapid Bloom Offboard Countermeasures (SRBOC) Chaff and Decoy Launching System,” Military Analysis Network (FAS), last modified June 30, 1999, accessed 09 February 2011, <http://www.fas.org/man/dod-101/sys/ship/weaps/mk-36.htm>.

<sup>52</sup> “MK-53 Nulka Decoy Launching System (DLS),” Military Analysis Network (FAS), last modified June 30, 1999, accessed 09 February 2011, <http://www.fas.org/man/dod-101/sys/ship/weaps/mk-53.htm>.

<sup>53</sup> “ES-3601 (United States), Naval signals intelligence (SIGINT), electronic support and threat-warning systems,” Jane’s, accessed February 09, 2011, <http://www.janes.com/articles/Janes-Radar-and-Electronic-Warfare-Systems/ES-3601-United-States.html>.

<sup>54</sup> “COMBATSS-21 Combat Management System,” Lockheed Martin, accessed February 10, 2011, <http://www.lockheedmartin.com/products/COMBATSS21CombatManagementSystem/index.html>.

<sup>55</sup> “TRS-3D multimode, C-band, ship-mounted, air and sea surveillance and target acquisition radar,” Deagal, accessed February 10, 2011, [http://www.deagal.com/Ship-Sensors/TRS-3D\\_a001487001.aspx](http://www.deagal.com/Ship-Sensors/TRS-3D_a001487001.aspx).

<sup>56</sup> “Soft Kill Weapon System (SKWS) decoy launching system,” Jane’s, accessed February 10, 2011, <http://www.janes.com/articles/Janes-Radar-and-Electronic-Warfare-Systems/Soft-Kill-Weapon-System-SKWS-decoy-launching-system-Denmark.html>.

<sup>57</sup> “Littoral Combat Ship (LCS) High-Speed Surface Ship, USA,” Navy Technology.com, accessed February 10, 2011, <http://www.naval-technology.com/projects/littoral/>.

<sup>58</sup> “Joint Intelligence Preparation of the Operational Environment, Joint Publication 2-01.3, Joint Forces Command, accessed February 11, 2011, [http://www.dtic.mil/doctrine/jel/new\\_pubs/jp2\\_01\\_3.pdf](http://www.dtic.mil/doctrine/jel/new_pubs/jp2_01_3.pdf).

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<sup>59</sup> "Mine Countermeasures Ships – MCM," U.S. Navy, accessed February 11, 2011, [http://www.navy.mil/navydata/fact\\_display.asp?cid=4200&tid=1900&ct=4](http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=1900&ct=4).

<sup>60</sup> "11-meter Naval Special Warfare Rigid Hull Inflatable Boat (RHIB)," U.S. Navy, accessed February 11, 2011, [http://www.navy.mil/navydata/fact\\_display.asp?cid=4200&tid=2200&ct=4](http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=2200&ct=4).

General Characteristics, 11 meter Naval Special Warfare RHIB:  
Propulsion: Dual Caterpillar 3126 DITA, 6 in-line cylinder diesel, turbocharged, aftercooled  
Length: 35 feet 11 inches (11 meters) (Overall, inflated tube)  
Beam: 10 feet 7 inches (3.2 meters) (sponsor inflated); 8 feet 9 inches (2.6 meters) (deflated)  
Displacement: 17,400 lbs, (7,892 kilograms)  
Draft: 2 feet 11 inches (0.9 meters)  
Speed: 40+ knots (nautical miles per hour) (64 kilometers/hour)  
Range: 200 nautical miles (370 kilometers)  
Crew: 3 and a SEAL squad  
Armament: M60 7.62mm machine gun, MK19 40mm, M2 .50 cal. machine gun

<sup>61</sup> "Spartan Scout Unmanned Surface Vehicle (USV)," Defense Industry Daily, last modified May 25, 2005, accessed February 10, 2011, <http://www.defenseindustrydaily.com/spartan-usvs-for-singapores-navy-0540/>.

<sup>62</sup> "AN/WLD-1 Remote Minehunting System (United States), Autonomous Semi-Submersibles," Jane's, accessed February 11, 2011, <http://www.janes.com/articles/Janes-Underwater-Security-Systems-and-Technology/AN-WLD-1-Remote-Minehunting-System-United-States.html>.

<sup>63</sup> "Littoral Combat Ship Platform Wholeness Concept of Operations (Revision C)."

<sup>64</sup> "Operational Maneuver from the Sea (OMFTS)," Global Security, accessed February 11, 2011, <http://www.globalsecurity.org/military/ops/omfts.htm>.

"The heart of Operational Maneuver from the Sea is the maneuver of naval forces at the operational level in order to deal a decisive blow directed against an enemy center of gravity—something that is essential to the enemy's ability to continue the struggle effectively."

<sup>65</sup> "Ship to Objective Maneuver," Global Security, accessed February 11, 2011, <http://www.globalsecurity.org/military/ops/stom.htm>,

"Ship-to-objective maneuver (STOM) is the tactic that provides the joint force commander (JFC) with the capability to employ the Marine air-ground task force (MAGTF) in an exponentially more efficient and potent manner, with the advantage and flexibility to achieve operational objectives across a broad range of operations. Current amphibious doctrine relies on

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attrition warfare and the philosophy of amphibious lodgment. The traditional phases and sequences involved in securing a beachhead often negate any advantage gained by maneuver at sea. STOM exploits emerging technology to employ the concepts of maneuver warfare, projecting the power of a combined arms force by air and surface means directly against operational objectives. STOM tactics focus on the principles of maneuver and sea-basing. Force structure and technology serve as enablers of STOW tactics and doctrine. The real power of STOW lies in the strength of the concept and the application of STOW principles.”

<sup>66</sup> Brigadier General Robert B. Neller, USMC, “Power Projection Requirements: Naval Mine,” ( Brief presented for the Mine Warfare Association, Panama City, FL, May 24, 2005), accessed February 23, 2011, [http://www.minwara.org/Meetings/2005\\_05/Proceedings/7-MINWARA%2024%20May%2005%20change%202.pdf](http://www.minwara.org/Meetings/2005_05/Proceedings/7-MINWARA%2024%20May%2005%20change%202.pdf).

<sup>67</sup> Jonathan F. Solomon, 2004, “Lethal in the littoral: A smaller, meaner LCS,” *U.S. Naval Institute Proceedings* 130, (January 2004): 36-39.

<sup>68</sup> Cebrowski and Hughes, “Rebalancing the Fleet,” 32.

One of the principle differences that the LCS departs from the *Streetfighter* concept is expendability. The *Streetfighter* ship would be cheap, small, and operate in large numbers. This would mean the Navy could risk losing ships in littoral combat where a few ship losses would not mean losing considerable combat power. With only 55 LCS hulls at \$450 million each, the Navy cannot afford to lose large numbers of ships. The NWDC LCS Concept of Operations calls for the LCS to operate mainly with an ESG or CSG but may conduct independent missions. The LCS will also rely on its numerous sensors to maintain superior battle space awareness and its high-speed, agility and stealth to avoid and evade littoral threats. Additionally, the installed mission package could be the deciding factor when exposed to a threat. The LCS with a specific mission package would be capable of defending itself against that associated mission threat but would be vulnerability to other littoral threats. It then becomes crucial that commanders properly access the threat prior to assigning a single-mission LCS to an operation. Since it will be hard to anticipate threats in the highly active littorals, and with 55 hulls, it would be possible to deploy LCS in pairs or squadrons with different mission packages to allow for mutual protection.

<sup>69</sup> U.S. Government Accountability Office, “Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships,” GAO-05-255, (U.S. Government Accountability Office (GAO), Washington, DC, March 2005), 31.

<sup>70</sup> “Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships,” 4.

<sup>71</sup> “The USA’s New Littoral Combat Ships,” *Defense Industry Daily*, last modified January 19, 2011, accessed 27 February 2011, <http://www.defenseindustrydaily.com/the-usas-new-littoral-combat-ships-updated-01343/>.

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<sup>72</sup> “Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships,” 42.

<sup>73</sup> Ronald O’Rourke, “Navy Littoral Combat Ship (LCS) Program: Background, Issues, and Options for Congress,” CRS Report RL33741, (Congressional Research Service (CRS), Washington, DC, October 14, 2010), 22-23, accessed February 28, 2010, <http://www.fas.org/sgp/crs/weapons/RL33741.pdf>

“Undated Navy point paper provided to CRS by Navy Office of Legislative Affairs on September 8, 2010. In response to a part of the GAO report that discussed the initial deployment of LCS-1, the point paper stated: The intent was to employ the unique capabilities of this new class of warship as soon as practical in the Fleet, to gain real operational experience and to assess LCS’ minimal manning strategy. During her maiden deployment, two years earlier than originally planned, USS *Freedom* was outfitted with a tailored Surface Warfare Mission Package. She deployed with a Helicopter Sea Combat Squadron 22 detachment and a U.S. Coast Guard Law Enforcement Detachment. *Freedom* successfully conducted four drug seizures, netting more than five tons of cocaine, detained nine suspected drug smugglers, and disabled two “go-fast” drug vessels. During deployment, USS *Freedom* also performed integrated at-sea operations with the USS *Carl Vinson* (CVN 70) Carrier Strike Group, performed at-sea maneuvers with the former-USS *McInerney* (FFG 7), and conducted several theater security cooperation port visits in Latin America. Operations continued over the summer, when USS *Freedom* participated in the Rim of the Pacific exercise, returning to homeport on Aug. 10, 2010. Impact on Testing: There are no changes to the overall scope of LCS 1 testing as a result of early deployment. Any delays to the overall post delivery testing plan were offset by the extensive depth and breadth of knowledge gained during deployment. In evaluating options for deploying *Freedom* earlier than originally scheduled, the Navy looked at several key factors: ship materiel condition, test plan acceleration, ship sustainment, integrated support plan, and crew training and certification. Early deployment brought LCS operational issues to the forefront much sooner than under the original schedule, some of which would not have been learned until two years on. Through this process, Navy “learned by doing.” Every aspect of this ship and program is new, from the operational concepts, through crew training and certification processes, to the support and sustainment strategies. Early deployment provided a vital opportunity to collect data in real-world operational scenarios. This data will be invaluable in the ongoing effort to accomplish the larger LCS fleet integration strategy. LCS is a key component of the 21st century Navy. Early deployment of LCS 1 was a tremendous opportunity to test the ship in a real-world environment and begin integrating this essential ship into our fleet.”

<sup>74</sup> U.S. Government Accountability Office, “Littoral Combat Ship: Actions Needed to Improve Operating Cost Estimates and Mitigate Risks in Implementing New Concepts,” GAO-10-257, (U.S. Government Accountability Office, Washington, DC, February 2010), 26.

“Preventive maintenance refers to periodic tasks to keep equipment in good condition such as inspections, lubrication, or calibration. Facilities maintenance includes deep cleaning and preservation. Due to the small core crew size, a significant amount of maintenance has moved off the ship. The initial analysis was that 20 to 30 person-years of preventive

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maintenance would need to be moved off ship. According to the Navy's LCS concept, the core crew expects to do little or no corrective maintenance and minimal preventive and facilities maintenance. The rest is done during in-port periods—by the crew or contractors—or by teams that fly out to the ship to perform maintenance during crew turnover periods.”

<sup>75</sup> Susan Henson, “LCS Crew to be Hybrid Sailors,” *All Hands Magazine*, July 12, 2004: 1.

<sup>76</sup> “Littoral Combat Ship: Actions Needed to Improve Operating Cost Estimates and Mitigate Risks in Implementing New Concepts,” 23-24.

“Due to the longer training time required to prepare LCS sailors, the Navy's Personnel Command must identify personnel 18 to 24 months prior to when they need them to report to the LCS crew. For other surface ships, the Personnel Command needs to identify personnel only 5 to 9 months ahead of time. Personnel Command officials stated that they must manually identify the personnel for LCS since the computer system normally used to identify personnel can only identify personnel up to 12 months in advance. Due to the increased workload resulting from the manual process, the Navy Personnel Command has set up a separate office specifically to handle LCS personnel assignments and added eight positions. Officials stated that they would likely need more personnel as more ships and mission packages enter service. Since the average annual turnover rate is about one-third, according to Navy officials, the Personnel Command will have to identify a significant number of replacement sailors manually each year to support the LCS program.

Navy officials noted that some positions on an Aegis ship also have lengthy training requirements, such as training for sailors who work on the Aegis radar. Since this type of equipment is not on LCS, the related positions were not part of the study sample.”

<sup>77</sup> John P. Baggett, Lieutenant, USN, “Logistical Analysis of the Littoral Combat Ship (LCS) Operating Independently in the Pacific,” (Master Of Science In Operations Research thesis, Naval Postgraduate School, March 2008), 35-40.

The endurance analysis shows that both the GD and LM LCS do not meet the 1500 NM endurance objective level range at 50 knots. At the economical speed of 20 knots, only the GD LCS meets the objective endurance level range of 4300 NM. Both designs meet only the threshold endurance level of 1000 NM at 40 knots sprint speed. Only the GD LCS satisfies the threshold level of 3500 NM range at a speed greater than 18 knots. The analysis shows that the most economical speed (the speed at which the LCS has the longest range) for both ships is below the threshold level of 18 knots. For both designs, the most economical speed is 7 knots. While the LM LCS has a higher economical speed of 17 knots versus the GD LCS speed of 13 knots, the GD LCS can travel twice the range due to a greater fuel capacity of 179,592 gallons versus the LM LCS storage capacity of 111,846 gallons.

<sup>78</sup> “Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships,” 18.

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The logistics support required to meet the Navy's goal of changing LCS mission packages is within 4 days of arriving at an appropriate facility. A number of factors can influence this timeline, including; the location to store the mission packages, how are modules to be transported, and the proximity of LCS operating areas to port facilities and a forward operating base.

<sup>79</sup> Ronald O'Rourke, "Navy DD(X), CG(X), and LCS ship Acquisition Programs: Oversight Issues and Options for Congress," CRS RL32109, (Congressional Research Service (CRS), Washington DC, 2005), 147.

<sup>80</sup> "Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships," 16.

<sup>81</sup> Department of Defense, Director, Operation Test and Evaluation, "FY 2009 Annual Report," (Washington DC, December 2009), 147.

<sup>82</sup> Jeffery Levinson and Randy Edwards, *Missile Inbound: The Attack on the Stark in the Persian Gulf*, (Maryland: Naval Institute Press, 1997), 2.

<sup>83</sup> Evan Thomas and Sharon Squassoni, "Desperate Hours: The Blast Claimed 17 Lives and Crippled a Destroyer, The Inside Story of the Heroic Bid to Save the USS *Cole*," *Shipmate*, June 2001: 2, 9-13.

<sup>84</sup> U.S. Department of the Navy, Officer of the Chief of Naval Operations, "Navy Tactics, Techniques, and Procedures (NTTP), Surface Ship Survivability," NTTP 3-20.31, (Newport, RI: DCNO, October 2004).

This tactical publication outlines the use of portable damage control equipment in damage control efforts to fight flooding and fire on a ship.

<sup>85</sup> Robert O. Work, "The US Navy: Charting a Course for Tomorrow's Fleet," (Center for Strategic and Budgetary Assessments, Washington, DC, 2008), 28, accessed February 16, 2011, <http://www.csbaonline.org/4Publications/PubLibrary/R.20090217.The US Navy Charti/R.20090217.The US Navy Charti.pdf>.

<sup>86</sup> Michael G. Mullen, Admiral, USN, "National Military Strategy," (Chairman of the Joint Chiefs of Staff, Washington DC, February 08, 2011), 2, 10, 18, 20.

<sup>87</sup> "Viper Strike Laser Guided Weapon," Defense Update.com, accessed February 21, 2011, <http://www.defense-update.com/directory/viper-strike.htm>.

<sup>88</sup> "Advanced Precision Kill Weapon System," Global Security.org, accessed February 21, 2011, <http://www.globalsecurity.org/military/systems/munitions/apkws.htm>.

<sup>89</sup> "RQ-8B Fire Scout helicopter (VTUAV)," Defense Update.com, accessed February 21, 2011, <http://defense-update.com/products/f/FireScout.htm>.

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<sup>90</sup> "Griffin missile," Defense Update.com, accessed February 21, 2011, [http://defense-update.com/products/g/31122010\\_griffin\\_sgm.html](http://defense-update.com/products/g/31122010_griffin_sgm.html).

<sup>91</sup> "Lockheed Martin AGM-114 Hellfire missile," Andreas Parsch *Directory of U.S. Military Rockets and Missiles*, last modified June 24, 2009, accessed February 10, 2011, <http://www.designation-systems.net/dusrm/m-114.html>.

"The AGM-114 *Hellfire* is a fire-and-forget anti-armor missile mainly for use by helicopters and UAVs.

Specifications:

Dimensions: Weight 100–108lb (45.4–49kg), Length 64 in (163 cm), Diameter 7 in (17.8 cm), Wingspan 13 in (33 cm)

Warhead: High Explosive Anti-Tank (HEAT); 20 lb (9 kg) tandem anti-armor

Metal augmented charge (MAC); 18 lb (8 kg) shaped-charge Blast Fragmentation Engine

Solid-fuel rocket

Range: 546 yd – 5 mi (500 m – 8 km)

Speed: Mach 1.3 (950 mph; 425 m/s)

Guidance system: Semi-active laser homing millimeter wave radar seeker

Launch platform: Rotary, fixed-wing, unmanned combat air vehicles, tripods, ships, and ground vehicles."

<sup>92</sup> "GAU-21 design specifications," Navy Weapons.com, accessed February 21, 2011, [http://www.navyweapons.com/Weapons/WNUS\\_50cal-M3M\\_MG.htm](http://www.navyweapons.com/Weapons/WNUS_50cal-M3M_MG.htm).

<sup>93</sup> "M134 Gatling Gun design specifications," M134, accessed February 21, 2011, at <http://www.m134.com/>.

<sup>94</sup> "The Navy of Singapore has deployed the Protector USV in Iraqi waters," Defense Industry Daily, accessed February 22, 2011, <http://www.defenseindustrydaily.com/spartan-usvs-for-singapores-navy-0540/>.

<sup>95</sup> "Delilah HL- Helicopter Launched, SL-Ship Launched, Stand-Off Surface Attack Cruise Missile," *Israel Military Industries*, (Israel Military Industries, Ltd, 2011), accessed February 22, 2011, <http://www.imi-israel.com/home/doc.aspx?mCatID=65739>,

<sup>96</sup> "MK 32 Surface Vessel Torpedo Tube (SVTT)," Military Analysis Network, last modified June 30, 1999, accessed February 22, 2011, <http://www.fas.org/man/dod-101/sys/ship/weaps/mk-32.htm>.

<sup>97</sup> "Torpedoes: Mark 46, Mark 48, Mark 50," About U.S. Military.com, accessed February 22, 2011, <http://usmilitary.about.com/library/milinfo/navyfacts/bltorpedoes.htm>.

<sup>98</sup> Len F. Picotte, Rear Admiral, USN(Ret), and Thomas B. Holmes, Commander, USN(Ret), "Amphibious Forces: The '9-1-1' Number Has Never Been Busier! So Now What?" *Marine Corps Gazette*, March 2003.

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<sup>99</sup> "International Variant LCS brochure," General Dynamics, accessed February 23, 2011, <http://www.gdlcs.com/gd-lcs-solution/international-variant>.

<sup>100</sup> "RIM-162 Evolved Sea Sparrow Missile (ESSM)," Global Security.org, accessed February 23, 2011, <http://www.globalsecurity.org/military/systems/munitions/rim-162.htm>.

<sup>101</sup> "SM missile," Global Security.org, accessed February 23, 2011, [www.globalsecurity.org/military/systems/munitions/sm.htm](http://www.globalsecurity.org/military/systems/munitions/sm.htm).

<sup>102</sup> "Vertical Launch Anti-Submarine Rocket ASROC (VLA) Missile," U.S. Navy, accessed February 23, 2011, [http://www.navy.mil/navydata/fact\\_display.asp?cid=2200&tid=1500&ct=2](http://www.navy.mil/navydata/fact_display.asp?cid=2200&tid=1500&ct=2).

<sup>103</sup> "Boeing (McDonnell Douglas) AGM/RGM/UGM-84 *Harpoon*," Andreas Parsch *Directory of U.S. Military Rockets and Missiles*, last modified July 08, 2008, accessed February 10, 2011, <http://www.designation-systems.net/dusrm/m-84.html>.

<sup>104</sup> "MK 15 Phalanx Close-In Weapons System (CIWS)," Military Analysis Network, last updated July 09, 2003, accessed February 22, 2011, <http://www.fas.org/man/dod-101/sys/ship/weaps/mk-15.htm>.

<sup>105</sup> "General Dynamics Multi-mission hull design specifications," General Dynamics, accessed February 23, 2011, <http://www.gdlcs.com/sites/default/files/MMC-DataSheet.pdf>.

<sup>106</sup> "Multi-Mission Surface Combatant," Lockheed Martin, accessed February 23, 2011, <http://www.lockheedmartin.com/data/assets/ms2/pdf/SCSbrochure.pdf>.

<sup>107</sup> "AN/SPY-1 radar system," Military Analysis Network, last updated June 16, 2000, accessed February 23, 2011, <http://www.fas.org/man/dod-101/sys/ship/weaps/an-spy-1.htm>.

<sup>108</sup> "MK 41 Vertical Launching System (MK 41 VLS)," Lockheed Martin, accessed February 23, 2011, <http://www.lockheedmartin.com/products/MK41VerticalLaunchingSystem/index.html>.

<sup>109</sup> "BGM-109 Tomahawk," Military Analysis Network, last updated October 21, 2010, accessed February 22, 2011, <http://www.fas.org/man/dod-101/sys/smart/bgm-109.htm>.

<sup>110</sup> "Multi-Mission Surface Combatant."

<sup>111</sup> "Navy Special Warfare Swimmer Delivery Vehicle design specifications," Global Security.org, accessed February 24, 2011, <http://www.globalsecurity.org/military/systems/ship/sdv.htm>.

<sup>112</sup> "Mark V Special Operations Craft," U.S. Navy, accessed February 24, 2011, [http://www.navy.mil/navydata/fact\\_display.asp?cid=4200&tid=1700&ct=4](http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=1700&ct=4).



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<sup>113</sup> Janice Karin, "Special Operations Gets Hummingbird UAV," *The Future of Things to Come*, December 01, 2008, accessed February 10, 2011, <http://thefutureofthings.com/pod/5877/special-operations-gets-hummingbird-uav.html>.

"The Boeing, A160T Hummingbird unmanned aerial vehicles is 35 feet long with a 36-foot rotor diameter. It uses a Pratt & Whitney PW207 turbo shaft engine and designed to fly 2,500 nautical miles (2,900 regular miles) with a payload of 300 pounds (larger payloads are supported for shorter distances). It can remain airborne for 24 hours, with speed of 160 mph (140 knots) at altitude of 30,000 ft. Future versions could fly as high as 55,000 ft and remain aloft for 48 hours."

<sup>114</sup> "Scan Eagle UAS design specifications," U.S. Air Force, accessed February 10, 2011, [http://www.af.mil/information/factsheets/factsheet\\_print.asp?fsID=10468&page=1](http://www.af.mil/information/factsheets/factsheet_print.asp?fsID=10468&page=1)

<sup>115</sup> "Military Analysis Network FAS, Cooperative Engagement Capability (CEC) AN/USG-2(V) Cooperative Engagement Transmission Processing Set."

<sup>116</sup> "United States Navy's MQ-4C Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System (UAS) program," Northrop Grumman Aerospace Systems Battle Management & Engagement System, Northrop Grumman, Bethpage, NY, last modified June 16, 2009, accessed February 09, 2011, <http://www.as.northropgrumman.com/products/bams/index.html>,

The Navy MQ-4 C Broad Area Maritime Surveillance (BAMS) Unmanned Aircraft System (UAS) provides persistent maritime Intelligence, Surveillance, and Reconnaissance (ISR) data collection and dissemination capability to the Maritime Patrol and Reconnaissance Force (MPRF). The MQ-4C BAMS UAS is a multi-mission system to support strike, signals intelligence, and communications relay as an adjunct to the MMA/P-3 community to enhance work force, training, and maintenance efficiencies worldwide. The BAMS UAS will provide persistent maritime Intelligence, Surveillance, and Reconnaissance (ISR) data collection and dissemination capability to the force that will play a significant role in the Sea Shield and FORCEnet pillars of Sea Power 21. In the Sea Shield role, BAMS UAS's on-station persistence enables unmatched awareness of the maritime battle space by sustaining the maritime Common Operational Picture. As a Fleet Response Plan enabler, BAMS UAS will act as a trip wire for surge forces. In its FORCEnet role, BAMS UAS will support decision superiority precision and mobility while providing IP-based wideband transponder services that net the battle space. The BAMS UAS's ability to perform persistent ISR within a range of 2,000nm allows the P-8A and EP-X aircraft to focus on their core missions, Anti-Surface Ship Warfare (ASuW)/weapons employment and Multi-Intelligence (INT) operations respectively.

General characteristics:

Crew: Unmanned

Length: 47.6 ft in (14.5 m)

Wingspan: 130.9 ft in (39.9 m)

Height: 15.3 ft in (4.7 m)

Gross weight: 32,250 lb (14,628.4 kg)

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Powerplant: 1 × Rolls-Royce AE 3007 turbofan, 6,495-8,917 lbf (28.9-39.7 kN)  
Maximum speed: 357 mph ( km/h) (310 kts)  
Endurance: 30 hours  
Service ceiling: 60,000 ft (18,288 m)  
Primary Function: Persistent Maritime ISR  
Range: >9,550 nautical miles (>18,427 kilometers), max unrefueled range  
Crew: 4 per ground station (Air Vehicle Operator, Mission Commander/Comms.,  
2 Sensor Operators)  
Payloads: Communications relay capability, beyond line of sight and line of sight  
communications and the following 60-degree Field Of Regard (FOR) sensors: Multi-  
Function Active Sensor (MFAS) Maritime Radar, Electro-Optical / Infrared (EO/IR)  
sensor, Automatic Identification System (AIS) receiver and Electronic Support Measures  
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<sup>117</sup> Ronald O'Rourke, "Navy Littoral Combat Ship (LCS) Program: Background, Issues,  
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<sup>118</sup>"HIMARS design specifications," Army Technology.com, accessed February 10,  
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<sup>119</sup> Bettina H.Chavanne, "USMC Commandant Suggests LCS Fire Support," *Aviation  
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Research, as stated in the preface, has been challenging due to the non-release of proprietary ownership information under the contract competition between the General Dynamics and Lockheed Martin Design teams to build the LCS. Now that the contract has been issued to both companies for ten LCS hulls each, this future propriety information will be easier to obtain since there is no longer an active bid competition. Since the LCS is a current subject, most research has been on the internet and military technical sites that focuses on the design information and evaluations of the actual seaframes, and LCS concepts of operation.

The chronology of LCS development indicates how much confusion was in the LCS funding and procurement process. From these arguments and discussions, a host of research studies were undertaken to answer congressional inquiries about the LCS problems, capabilities and costs, and to determine if there was a more cost effective substitute that could fill the capabilities gaps in the littorals. These research papers and articles, from the Congressional Budget Office, U.S. General Accounting Office, and Congressional Research Service (CRS) by Undersecretary of the Navy, Robert Work, and Ronald O'Rourke, have been critical sources of information to formulate this paper's discussion about shipbuilding plans, LCS historical development background, and the problems associated with the LCS contract process.

The builder websites were the main sources for much of the C4ISR and weapons capabilities for the seaframes. The Defense Industry Daily and Global Security websites, accessed mainly by defense manufacturing companies, proved to be valuable sources of information regarding weapon system capabilities, research, and developments. Admiral Clark's, Vice Admiral Cebrowski's, and Captain Hughes's *Proceedings* articles provided the ideas under which the LCS concept of operations and possible operations were formulated.

Finally, the U.S. Navy's and USMC documents provided the context for future littoral missions, threats, and capability gaps that exist in the current force structure and the guidance for future operations. The asterisk indicates those references that are the foundations of this paper.

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